INSTRUCTION MANUAL

949XP-3-3987

California INSTRUMENTS

Invertron® AC POWER EQUIPMENT

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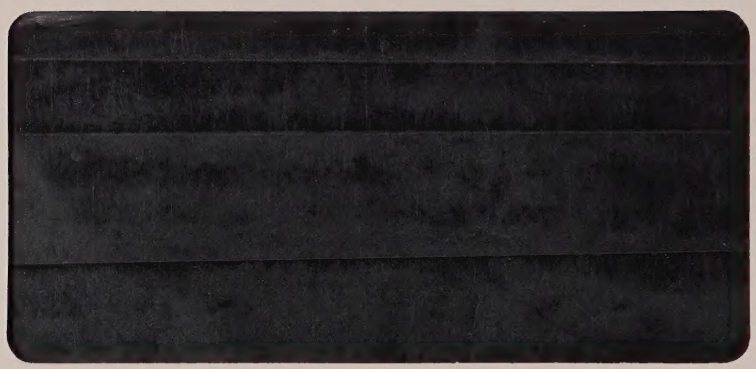

California INSTRUMENTS

INSTRUCTION MANUAL
949XP-3-3987

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NOTE:

ASSEMBLIES, SCHEMATICS AND PARTS LISTS MAY DIFFER FROM THIS MANUAL IF MODEL NUMBER HAS A 3 OR 4 DIGIT SUFFIX. SEE SERIAL NUMBER TAG FOR PROPER IDENTIFICATION.

EXAMPLE

849TA-1-4-2-8-1-3888

MODEL NUMBER

OPTIONS (IF APPLICABLE)

4 DIGIT SUFFIX

MANUAL ADDENDUM

949XP-3987

1.0 GENERAL:

The 949XP-3987 is similar to the standard 949XP Oscillator with the following exceptions:

1. Default value for programmable amplitude is zero voltage.

2. Inhibit faults for 10 seconds after the program of an amplitude value above 5 volts when the previous program value was less than 5 volts.

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Revision D
February 1989

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P/N 4949-960

INSTRUCTION MANUAL

949XP

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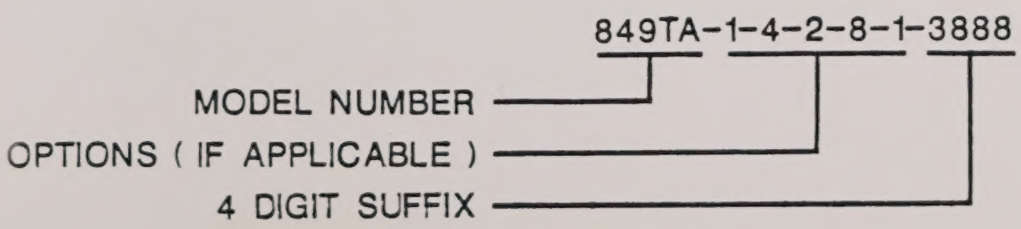
EXAMPLE



MODEL 949XP

Short Form Manual
(Full Instruction Manual begins on Page 1)

1.0 LOCAL PROGRAMING

1.1 GENERAL

The front panel keyboard will be enabled whenever the REMOTE light is extinguished.

The 949XP may be programmed by first selecting a display (screen) on the front panel display. Table 1 shows each of the screens and identifies each screen with a number.

Any screen except RMP (A) or RMP (B) may be selected after power-up by entering the screen number followed by depressing the ENT key.

While viewing any screen, the screens may be reviewed in a numerically increasing order by repeatedly depressing the MON key. The screens will be displayed in a numerically decreasing order by depressing the PRG key.

1.2 TO PROGRAM ANY OUTPUT PARAMETER

First select the program parameter screen by depressing the MNU key until the function you wish to change is displayed.

To select the Amplitude (AMP) screen from any screen except the SNC, CLK or WVF screens enter the following key sequence:

5 ENT

To select the Frequency screen (FRQ) enter the key sequence:

6 ENT

To select the Phase screen (PHZ) enter the key sequence:

7 ENT

1.2.1 TO PROGRAM THE OUTPUT AMPLITUDE

The output amplitude is programmed while the AMP screen (5) is selected.

While viewing the AMP screen the output amplitude is programmed to 115.5 volts by entering the following key sequence:

1 1 5 . 5 PRG ENT

To program .9 volts enter the key sequence:

ø . 9 PRG ENT

To simultaneously program phase A to 130, phase B to 120 and phase C to 110 enter the following key sequence:

1 3 0 A PRG 1 2 0 B PRG 1 1 0 C PRG ENT

1.2.2 TO PROGRAM THE OUTPUT FREQUENCY

The output frequency is programmed while the FRQ screen (6) is selected. To program the frequency to 60.23 Hz enter the following key sequence:

6 0 . 2 3 PRG ENT

To program the frequency to 1234 Hz enter the key sequence:

1 2 3 4 PRG ENT

1.2.3 TO PROGRAM THE OUTPUT PHASE ANGLE

The output phase is programmed while the PHZ screen (7) is selected.

To program phase C to 90.5 degrees relative to phase A enter the following key sequence:

9 0 . 5 PRG ENT

To simultaneously program phase B to 90 degrees and phase C to 180 degrees relative to phase A:

9 0 B PRG 1 8 0 C PRG ENT

TABLE 1
SCREENS

SCREEN NO.	NAME	ARGUMENT	DEFINITION
1	SNC	INT,EXT	Synchronize the output frequency to the external input.
2	CLK	INT,EXT	Select the clock source.
3	WVF	SNW,SQW	Program a sine wave (SNW) or square wave (SQW).
4	RNG	Range (Limit)	Select the high or low voltage range.
5	AMP	0.0 to RNG Limit	Program the output voltage amplitude.
6	FRQ	45.00 to high limit	Program the output frequency.
7	PHZ	0.0 to ±999.9	Program the phase angle relative to phase A or EXT SYNC.
8	CRL	0.0 to high limit	Program the output current limit in amps.
9	RMP(A)	DLY,STP,VAL	Parameters to ramp the independent parameter.
10	RMP(B)	STP,VAL	Parameters to ramp the dependent parameter.
11	ELT	H,M,S	949XP total accumulated running time.
16	VLT		Display for øA, B and C voltage.
17	CUR		Display for øA, B and C current.
18	PWR		Display for øA, B and C power.
19	PWF		Display for øA, B and C power factor.
20			Pointer for ADC calibration.
21			Pointer for power source to display volts.

TABLE 1 (continued
SCREENS

22			Pointer for power source to display current.
23			Pointer for power source to display power.

949XP POWER CONTROLLER

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SECTION 1 - GENERAL DESCRIPTION

1.1 INTRODUCTION

This manual contains information pertaining to the installation, operation and calibration of California Instruments' Model 949XP AC Power Controller.

1.2 DESCRIPTION

The Model 949XP AC Power Controller is a frequency, amplitude and phase controller designed to plug into all California Instruments' XP Series AC power sources. The frequency, amplitude and phase of the power source output may be locally controlled using a keyboard on the front of the controller, or remotely controlled through its IEEE-488 interface.

The controller output is a variable frequency, variable amplitude, variable phase AC voltage. It provides the three-phase input signal for the associated power source where it is amplified to produce the high-power, multi-phase output. Sense inputs for each of the three phases assures that the voltage at the remote sense point equals the programmed value. If the programmed voltage value cannot be maintained within specified limits, the controller reduces the power source output then displays an error message on its control panel. The displayed message indicates which of the phases has not been maintained at the programmed value. Microprocessor-controlled, digital logic is employed in the controller for frequency generation. Its sine wave outputs are produced by a precision digital-to-analog converter. Frequency accuracy is maintained by a quartz crystal whose temperature stability is ± 5 parts per million per degree celsius.

The Model 949XP AC Power Controller provides many features depending on the actual configuration purchased.

These features include:

- High-reliability CMOS design uses less than 2 watts of power.
- More than 20 programmable functions.
- Multi-page menu screen and 17 parameter screens for total system programming and monitoring.
- Independent control of amplitude, phase angle, frequency, voltage range and current limit.

- Master/Slave configurations for applications requiring more than 3 phases.

- 4 decades of frequency output with resolution to 0.01 Hz.

- Automatic frequency range changing.

- Amplitude, frequency, phase angle and current limit may be ramped incrementally via program control. Start, finish, step size and step duration are independently programmable.

- Sine or square wave output independently selectable on each phase.

- Two programmable voltage ranges.

- Simple IEEE-488 software using Abbreviated Plain English (APE).

- Alphanumeric prompting display is user-friendly; no reference codes are required.

- 32 character alphanumeric display.

- 20 key keypad for complete front panel control.

- Complete programming (including IEEE-488 bus address and calibration from the front panel) - no inside adjustments are needed.

- Non-volatile memory for instant set-up to pre-programming test parameters.

- Non-volatile and volatile registers for storage of programmable parameters.

- System diagnostics with error messages on front panel display.

- Internal clock tracks total elapsed time.

- Internal counter tracks the frequency of an external signal from 45 Hz to 450 Hz to provide a low distortion output when in the external sync mode.

- Display of three phases of output: Voltage, Current, Power and Power factor.

1.3 SPECIFICATIONS

Operating specifications for the Model 949XP are shown in Table 1-1.

SPECIFICATIONS

MODEL 949XP AC POWER CONTROLLER

TABLE 1-1

Amplitude Program Independent or simultaneous voltage programming on each phase.

VOLTAGE RANGES:	67.5/135.0 Optional
VOLTAGE ACCURACY: (25 degrees C ±1 degree C) (Based on Full-Wave Avg)	±0.1% of full scale from default voltage to full scale (±0.2% above 5 KHz)
TEMPERATURE COEFFICIENT:	±0.01% of full scale per degree C average from 25 degrees C.
LOAD REGULATION:	±0.01% of full scale no-load to full load.
LINE REGULATION:	±0.01% of full scale for ±10% line change
LONG TERM STABILITY: (25 degrees C ±5 degrees C At Constant Line and Load)	±0.02% of full scale per 1000 hrs.
DISTORTION:	Less than 1% from 5% of full scale to full scale.
DEFAULT VOLTAGE:	5.0 Volts.
DEFAULT RANGE:	Either range of specified range pair.

FREQUENCY PROGRAM

FREQUENCY RANGE:	Four decade resolution from 45.00 (or other low limit) to 9999 Hz. (or other high limit)

FREQUENCY RESOLUTION:	0.01 Hz from 45.00 to 99.90 Hz 0.1 Hz from 100.0 to 999.9 Hz 1.0 Hz from 1000 to 9999 Hz
FREQUENCY ACCURACY: (25 degrees C ±1 degree C)	±0.001% of programmed value
TEMPERATURE COEFFICIENT:	±5ppm/degrees C from 25 degrees C
LONG TERM STABILITY: (25 degrees C ±1 degree C)	±15 PPM of Programmed Value per Year.
DEFAULT (Initial Value):	ANY
PHASE ANGLE: (Phase B and C relative to A)	0 to ±999.9 degrees in .1 increments
DEFAULT (Phase C)	ANY, but 0 defines Single Phase Any value except 0 and 120 defines Two Phase 120 defines Three Phase
PHASE ACCURACY:	±1 degree; add 0.5 degrees per KHz above 2 KHz

DISPLAY:

DATA: Two lines, 16 characters long, of alphanumeric information

SCREEN	PARAMTERS
ALM	RNG,LLM,HLM
AMP	A,B,C
PHZ	A,B,C
CRL	A,B,C
ELT	H,M,S
CFG	LSN,CFB,PHZ
FLM	FRQ,LLM,HLM
VLT	A,B,C
FRQ	
WVF	SNW,SQW
RNG	A,B,C
SNC	INT,EXT
CLK	INT,EXT
CAL	A,B,C
CUR	A,B,C
PWR	A,B,C
PWF	A,B,C
MNU	

LOCAL CONTROL:	20-key keyboard
REMOTE PROGRAMMING:	
	IEEE-488-1978 SUBSETS: SH1, AH1, T6, L3, SR1, RL2, DC1, DT1
	IEEE-728-1982 OPERATING CODES AND FORMATS:
	NUMERIC REPRESENTATION; NR1, NR2 OR NR3. HEADERS; HR1 OR HR2 (UPPER OR LOWER CASE) MESSAGE SEPARATORS; SR1
DATA TRANSFER RATE:	200K bytes/second using DMA methods
DMA BUFFER SIZE:	128 bytes
END OF STRING:	Standard: (CR), (LF) or (END) Field Optional: (LF) or (END) Field Optional: (CR) or (END)
ERROR MESSAGES (Status Byte):	Data Display message and status byte.
STATUS BYTE (Decimal):	FAULT
64	Phase A
65	Phase B
66	Phase A,B
67	Phase C
68	Phase A,C
69	Phase B,C
70	Phase A,B,C
71	Current Limit
72	Current Limit A
73	Current Limit B
74	Current Limit A,B
75	Current Limit C
76	Current Limit A,C
77	Current Limit C,B
78	Current Limit A,B,C
79	
80	Keyboard Entry 0 SRQ
81	Keyboard Entry 1 SRQ
82	Keyboard Entry 2 SRQ
83	Keyboard Entry 3 SRQ
84	Keyboard Entry 4 SRQ
85	Keyboard Entry 5 SRQ
86	Keyboard Entry 6 SRQ
87	Keyboard Entry 7 SRQ

88	Keyboard Entry 8 SRQ
89	Keyboard Entry 9 SRQ
90	Amplitude Range Limit Error
91	Amplitude Range Error
92	Frequency Range Error
93	Phase Range Error
94	Current Range Error
95	Ramp Range Error
96	Program Syntax Error
97	Bus message sent with Controller in Local
98	EXT SNC Frequency Limit
99	ROM SUM Check Error
100	Exceeds DMA buffer size

PROGRAM SYNTAX:	ABBREVIATED PLAIN ENGLISH
ALM	Amplitude Limit
AMP	Amplitude
CAL	Calibrate
CFG	Configuration
CLK	Clock
CRL	Current Limit
CUR	Current
DLY	Delay
ELT	Elapsed Time
EXT	External
FLM	Frequency Limit
FRQ	Frequency
HLM	High Limit
INT	Internal
LLM	Low Limit
MNU	Menu
PHZ	Phase
PRG	Program
PWF	Power Factor
PWR	Power
REC	Recall
REG	Register
RNG	Range
SNC	Synchronize
SNW	Sine Wave
SQW	Square Wave
SRQ	Service Request
STP	Step
TLK	Talk
TRG	Trigger
VAL	Value
VLT	Voltage
WVF	Waveform
#	Present Value

DATA FORMAT:	Scientific notation or explicit point

MEASUREMENT SPECIFICATIONS

VOLTS

RANGE:	400.0 volts / 40.00
RESOLUTION:	0.1 Volt / 0.01 volt
ACCURACY:	±1 Volt to 5000 Hz ±2 Volts to 9999 Hz
TEMPERATURE COEFFICIENT:	±0.027 Volts per degree C.

CURRENT

RANGE:	400.0 Amps / 40.00 Amps / 4.000 Amps
RESOLUTION:	0.1 Amp / 0.01 Amp / 0.001 Amp
ACCURACY:	±1 Amps to 5000 Hz ±2 Amps to 9999 Hz
TEMPERATURE COEFFICIENT:	±0.016% of full scale current per degree C.

POWER

RANGE:	10.00 KW. / 1.000 KW / 100 Watts
RESOLUTION:	.01 KW / 0.001 KW / 0.1 W
ACCURACY:	±1 KW to 5000 Hz ±2 KW to 9999 Hz
TEMPERATURE COEFFICIENT:	±0.06% of full scale per degree C.

POWER FACTOR

RANGE:	0.000 to 1.000

1.4 INSTRUMENTS IDENTIFICATION

The Model 949XP is identified by specifying its phase, frequency upper limit, initialization frequency, voltage range and functional status of the unit with a five digit suffix.

949XP-X-X-X-X-X-X

CURRENT LIMIT AND MEASUREMENT
- 0 = No Programmable Current Limit or Measurement Capability
- 1 = Current Limit (100 Amp)
- 2 = Current Limit (100 Amp) and Measurement
- 3 = Current Limit (1 Amp) and Measurement
- 4 = Current Limit (10 Amp) and Measurement
- 5 = Current Limit (1000 Amp) and Measurement

MASTER OR SLAVE
- 0 = Standalone (Standard)
- 1 = Master
- 2 = Slave

OUTPUT VOLTAGE RANGE PAIRS

INITIALIZATION RANGE	SECONDARY RANGE
0 = 135.0	270.0 (Std)
1 = 30.0	60.0
2 = LO RANGE	HI RANGE
3 = 67.5	135.0
4 = 10.00	20.00
5 = 20.00	40.00
6 = SPECIAL	SPECIAL
7 = SPECIAL	SPECIAL
8 = 270.0	135.0 (Std)
9 = 60.0	30.0
10 = HI RANGE	LO RANGE
11 = 135.0	67.5
12 = 20.00	10.00
13 = 40.00	20.00
14 = SPECIAL	SPECIAL
15 = SPECIAL	SPECIAL

INITIALIZATION FREQUENCY
- 1 = 50 Hz
- 2 = 60 Hz
- 3 = 400 Hz
- 4 = Specify

OUTPUT FREQUENCY UPPER LIMIT
- 1 = 500.0 Hz
- 2 = 1000 Hz
- 3 = 2000 Hz
- 4 = 5000 Hz
- 5 = 9999 Hz
- 6 = Specify

PHASE
- 1 = 1 Phase
- 2 = 2 Phase
- 3 = 3 Phase
- 4 = 3 Phase Delta
- 5 = 1 Phase using Multiphase 949XP

1.4.1 OPTIONS

The modifications to the Model 949XP for the various options described by the model number are listed in Table 1-2.

1.5 ACCESSORY EQUIPMENT

An Extender Assembly, Part Number 4000-718, is available to permit test and adjustment of the Model 949XP external to the power source. An Extender Cable, Part Number 4849-203-1, is also used for the printed circuit boards.

SECTION 2 - INSTALLATION

2.1 GENERAL

This section describes upacking and installation requirements for the Model 949XP AC Power Controller.

2.2 UNPACKING

The Controller is shipped in a corrugated carton and supported within the carton by protective, cushioning material. If the carton has been damaged during transit, conduct a detailed inspection to determine if the Controller has also been damaged. If damage is in evidence, notify the carrier's agent immediately. Retain the Controller and the shipping carton in the same condition as received until it has been examined by the carrier's representative.

2.3 POWER REQUIREMENTS

The AC Power Controller obtains all of its operating power from DC power supplies in the XP Series power source. This power requirement is +8 volts DC at 400 MA for powering the digital circuitry and +18 volts DC at 100 MA and -18 volts DC at 100 MA for powering the analog circuitry.

CAUTION

Voltages up to 270 volts AC are present inside Power Sources. This equipment uses potentially lethal voltages

DEATH

On contact may result if safety precautions are not observed. Do not touch any of the internal circuits when power is applied.

2.4 FUSE REQUIREMENTS

Five fuses, F1 through F5 are contained in the Controller. They are located on the 4949-706 assembly and act as a ground-fault interrupt to protect other equipment connected to the IEEE-488 bus. Fuses A5F1 through A5F5 are Littlefuse type 275001.

2.5 INSTALLATION

CAUTION

REMOVE POWER FROM THE POWER SOURCE BEFORE INSTALLING OR REMOVING THE CONTROLLER.

The Controller consists of a mother board, and several circuit boards which plug into it, which contain the control circuits. The assembly is designed to mount in the front panel opening of the Power Source. Installation of the Controller is accomplished with the following procedure.

Verify that the control panel is properly connected to the Controller. Note the GPIB ribbon cable extending through the opening in the front panel of the Power Source. Lift the ribbon cable connector to the top of the opening and stretch the cable gently to keep it clear of the center of the opening. Engage the longest printed circuit board of the Controller (the one with gold plated card-edge fingers) into the guides behind the opening. Resistance will be encountered when the board engages the card edge connector. Push gently but firmly on the Controller to complete insertion of the circuit board in the card edge connector. Verify that the board is firmly seated in the connector. Insert the GPIB ribbon cable connector into the circuit board with the mating header.

Carefully plug the front panel assembly keyboard into the Controller mother board and fasten its two captive thumb screws.

2.6 STANDARD OPERATING MODES AND OPTIONS

The 949XP has the capability to operate in many different modes with a mixture of output parameters. It is necessary to ensure that these parameters are compatible with the companion power source. If the associated power sources are not compatible with the parameter that would normally be displayed on a screen, that screen will be inhibited.

2.6.1 WAVEFORM (Option)

Most standard power sources will not sustain a square wave waveform below approximately 400 Hz. Special power sources have been designed to accept a 60 Hz square wave.

Before programming a square wave below 400 Hz ensure the power source will sustain the waveform.

2.6.2 VOLTAGE RANGE

The 949XP has the capability to operate on several different voltage range pairs. The standard 949XP hardware is designed for the 135/270 range pair. For other range pairs refer to Table 2-1 for the component value changes.

TABLE 2-1

VOLTAGE RANGE OPTIONS

RANGE PAIR CODE	RNG LIMIT	4949-706 A5R1,R5	4949-706 A5R30,R31,R32,R33	4949-707 (IF USED) A1R25,R27,R28,R36
0*	135.0/ 270.0	10.2K	CIC522	10.2K
0	200.0/ 400.0	6.81	CIC522	6.81K
0	67.5/ 135.0	21K	CIC522	21K
1	20.00/ 40.00	6.81K	CIC523	6.81K
1	10.00/ 20.00	13.7K	CIC523	13.7K
8	270.0/ 135.0	10.2K	CIC522	10.2K
8	400.0/ 200.0	6.81K	CIC522	6.81K
8	135.0/ 67.5	21K	CIC522	21K
9	40.00/ 20.00	6.81K	CIC523	6.81K
9	20.00/ 10.00	13.7K	CIC523	13.7K

* NOTE: Standard Configuration

The voltage range pair full scale limits are displayed on the ALM screen. To select the ALM screen, refer to paragraphs 3.5.4 and 3.5.4.3.

The A value is the range pair code. To review the value depress the A key. The B value (LLM) is the limit for the low voltage range. The C value (HLM) is the limit for the high voltage range.

2.6.3 FREQUENCY LIMITS

The upper and lower frequency limits are shown on the FLM screen. Refer to paragraphs 3.5.4 and 3.5.4.4 for access to this screen. The Low Limit (LLM) can be reviewed by depressing the B key. The High Limit (HLM) can be reviewed by depressing the C key.

After power-up the A value of the FLM screen will be the output frequency.

2.6.4 CURRENT LIMITS

The standard 949XP software supports current limit programming.

To implement current limit programming the 949XP must be used with a power source compatible with this feature. In addition, IC A5U4 must be installed on the bottom PC assembly (4949-706).

2.6.5 PHASE INITIALIZATION

In the CFG screen the C value (PHZ) is used to set the power-up phase angle of phase C. If this value is any value except a 0 or 120 the 949XP will be configured with phase A and C as a two-phase system. It will ignore interrupt faults from phase B to allow operation with only two power sources.

The standard two-phase configuration is defined as C = 90 degrees

The three-phase delta configuration uses only two sources. It is defined as C = 60 degrees.

If the C value is "0" the 949XP will be configured as a single-phase system. With C set to 120 the 949XP will be configured as a three-phase system with three power sources and all interrupts enabled.

2.6.6 EXTERNAL SYNCHRONIZATION

The SNC screen allows the 949XP to operate in the External (EXT) SNC mode. This mode will allow the 949XP to synchronize to an external signal.

2.6.6.1 EXTERNAL SYNCHRONIZATION INPUT

When the EXT SNC mode is selected on screen 1 the 949XP will frequency lock and phase lock to an external TTL compatible signal. The external signal is applied to pins 8 (HI) and 1 (LO) J1 on the rear panel of any power source. The signal should have a 50% duty cycle and a frequency between the Low Limit value and 450 Hz.

In the EXT SNC mode the frequency of the external signal is displayed on the FRQ screen. If this signal changes frequency at a rapid rate the 949XP will track the frequency at a faster rate while not displaying the external frequency.

The phase of the phase A output relative to the External Synchronization input is programmed on the PHZ screen. This value is initialized at 90 degrees. When operating in this mode with a two or three phase system this value should not be programmed within 20 degrees of a zero crossing. (ex. 20<øA<160,200<øA<340)

2.6.7 EXTERNAL CLOCK

The External Clock (EXT CLK) mode of operation is selected from the CLK screen. This mode allows the 949XP to operate from the Clock and Lock signals from a master 949XP. This mode of operation allows multiphase systems to be configured with up to six outputs. The slave 949XP will program its phase A output relative to phase A of the master with the A value on the PHZ screen. Phase B and C of the slave 949XP remain programmed relative to phase A of the slave.

All phases of the slave 949XP will program relative to phase A of the master if jumper A5W1 is removed and A5 W2 is added on the bottom PC assembly (4949-706).

CAUTION

> Before selecting the EXT CLK mode ensure that the External Clock and Lock signals are applied to the coax connectors J5 and J6 respectively at the rear panel of the power source. Selecting this mode without the signals may result in damage to the power source.

Refer to Table 2-2 to configure the 949XP as a master or slave.

TABLE 2-2

949XP	JUMPER CONFIGURATION ASSEMBLY 4949-708
MASTER	W1, W4
SLAVE	W2, W3

2.7 POWER SOURCE INTERCONNECTION

All two-phase 949XP models (949XP-2-X-X-X-X and 949XP-4-X-X-X-X) use the phase A and C oscillator outputs.

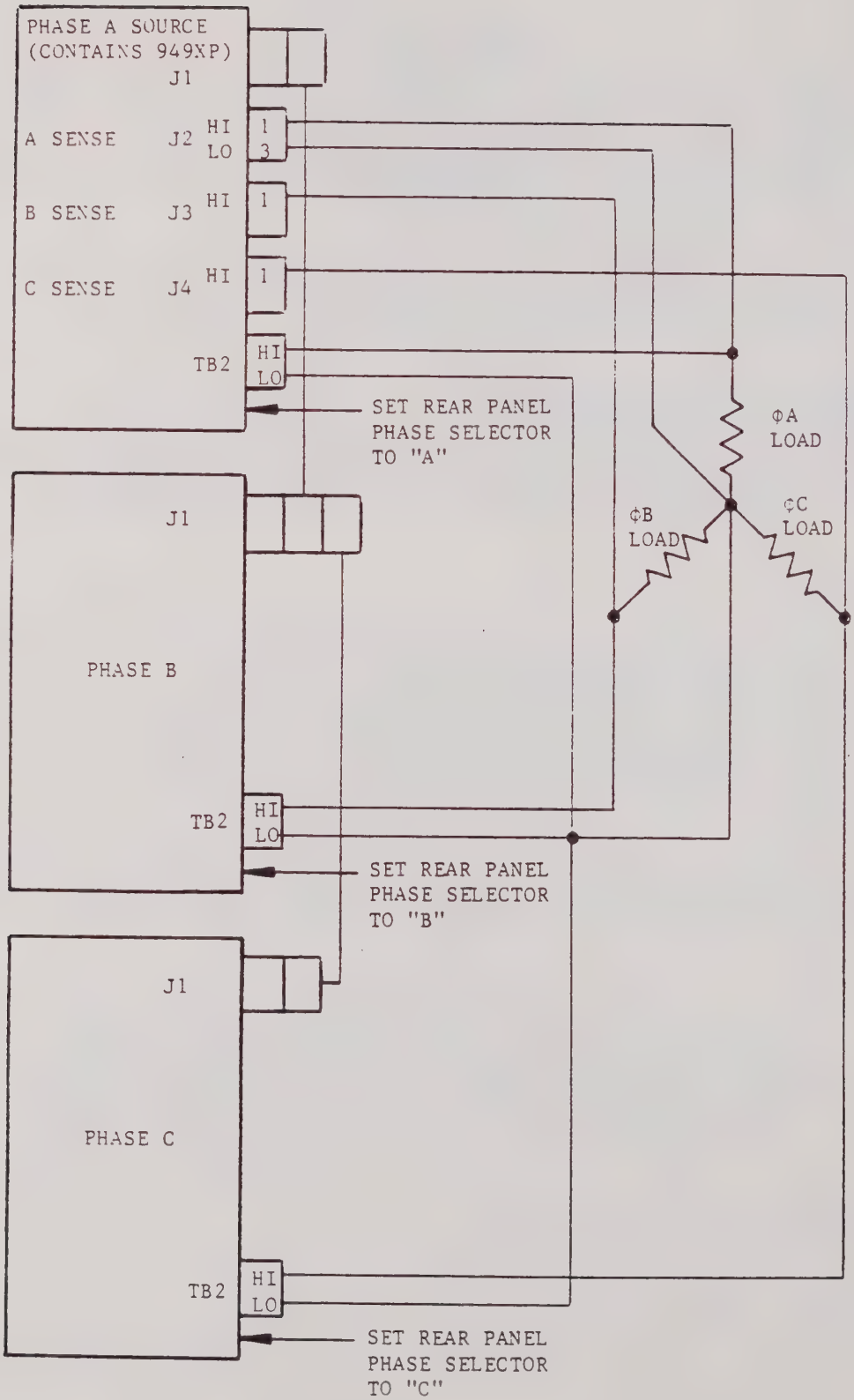


FIGURE 2-1
POLYPHASE POWER SYSTEM

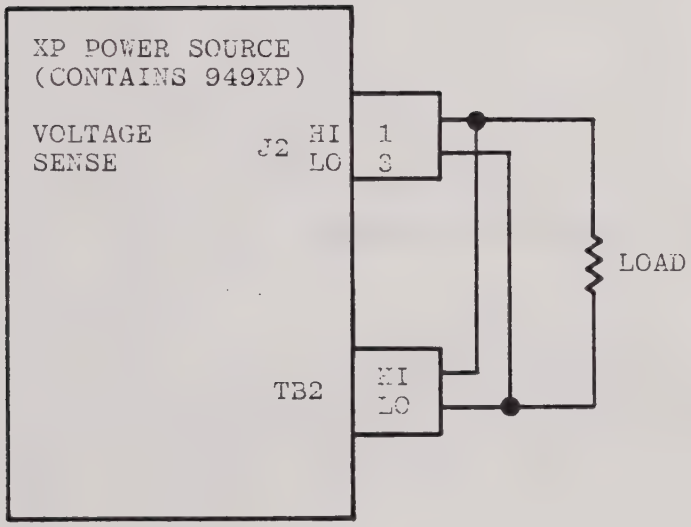


FIGURE 2-2
SINGLE-PHASE POWER SOURCE

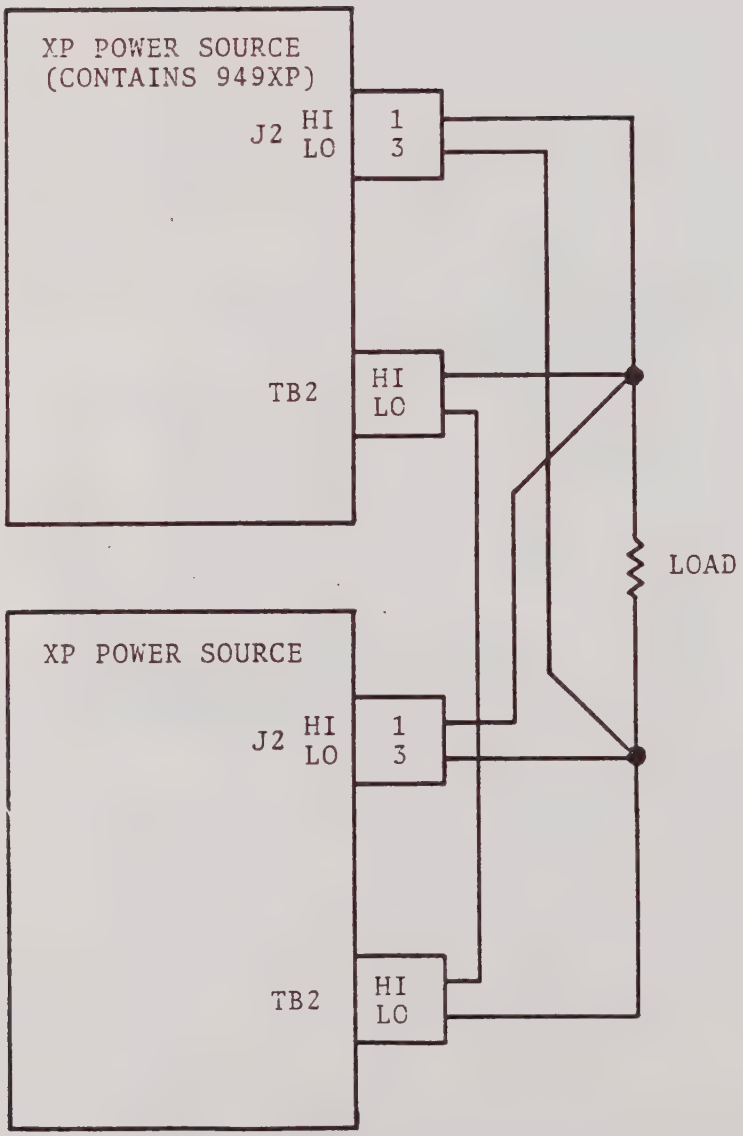


FIGURE 2-3
SINGLE-PHASE POWER SYSTEM

CAUTION

Failure to connect the sense leads across the load or to the power source output(s) will result in an error message on the 949XP's Display and the inability to program an output voltage.

CAUTION

REMOVE POWER FROM THE POWER SOURCE BEFORE REMOVING OR INSERTING THE PLUG-IN OSCILLATOR.

The remote sense leads for the phase A, B and C must be connected to the power source containing 949XP to connectors J2, J3 and J4 respectively. For single-phase, remote sense leads should be connected to J2 pin 1 to output HI and J2 pin 3 to output LO. For two-phase or open DELTA operation, connect remote sense leads as follows:

øA and øC Low to J2 pin 3
øA High to J2 pin 1
øC High to J4 pin 1

For three-phase operation see Figure 2-1.

For single-phase operation refer to Figures 2-2 and 2-3.

2.8 INTERFACE CONNECTIONS

The Model 949XP can be remotely controlled by an IEEE-488 bus controller. The controller must be connected to the bus connector J7 at the rear panel of the power source. Up to 15 instruments may be controlled by a bus controller at one time.

2.9 AMPLITUDE RANGE OPTIONS

The Model 949XP provides different voltage ranges. These voltage ranges are set up at the factory according to the 949XP model number suffix (refer to paragraph 1.4) to operate from 5 volts to 270 volts. The voltage ranges and their corresponding range codes are shown in Table 2-1. Only those ranges shown by * are standard. The other ranges require different hardware and should be used with the proper power source.

2.10 MASTER/SLAVE/CURRENT LIMIT/MEASUREMENT

The Model 949XP may be used with four hardware options: master, slave, current limit and measurement. The options cannot be added in the field. Additional components are required in the power source and 949XP for the measurement option. In addition, an IMC Instrument Module is required.

2.11 ACCEPTANCE TEST

To conduct these tests, the 949XP must be installed into an AC Power Source. The remote sense input must be connected as shown in Figure 2-1. Program any voltage and frequency combination and confirm the voltage accuracy to Figure 2-2. The voltage error for all the ranges is shown in Figure 2-2. The voltage error for both the 135 and 270 volt ranges is shown in Figure 2-2 separated by a slash (/).

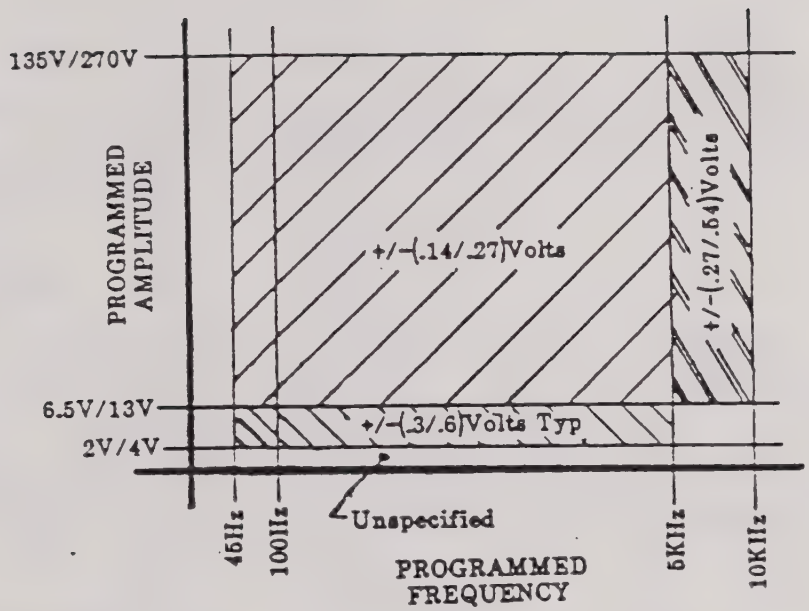
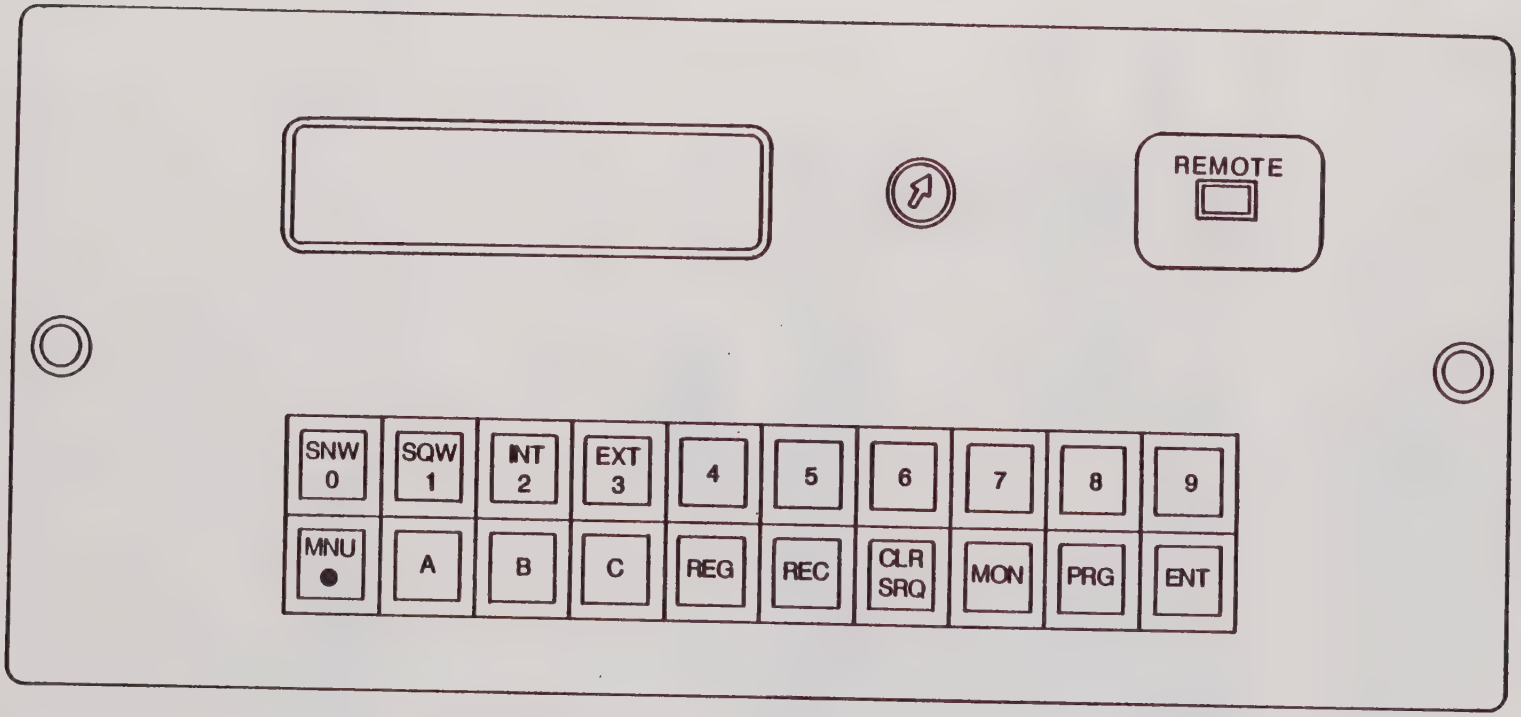


Figure 2-2
Performance Error Limits



NOTE: When depressing keys while programming be sure to hold the key in until a "beep" is heard.

FIGURE 3-1. KEYBOARD

SECTION 3 - OPERATION

3.1 GENERAL

This section of the manual describes the operation of the Model 949XP front panel display and keyboard. The operation of the IEEE-488 interface is also explained. Several program examples using the Hewlett Packard Series 80 Controller are also shown.

3.2 DISPLAY

The display is a liquid crystal display that offers two 16 character long lines of alphanumeric information. Each display presentation (screen) shows the programmed output parameters and error messages.

3.3 KEYBOARD

All local programming is performed on a 20 key keyboard. Refer to Figure 3-1 for a pictorial of the keyboard. There are eleven number and decimal point keys five of which have double functions. There are three phase select (A,B,C) keys, one register program (REG) key, one register recall (REC) key, one menu (MNU) key, one service request/clear (SRQ/CLR) key, a program (PRG) key a monitor (MON) key and an enter (ENT) key. Table 3-1 describes the function of the twenty keyboard keys.

3.4 ERROR MESSAGES

There are three types of error messages displayed on the 949XP for range errors, syntax errors and output faults. The three types are shown in Figure 3-2. The display will identify the parameter, the output and the equivalent Status Byte value identified for the error.

3.4.1 RANGE ERROR MESSAGE

If an out-of-range value is programmed for any of the programmable parameters (AMP, RNG, FRQ, PHZ, CRL) a RANGE ERROR message display will be shown. In addition a Range Error message will be generated for any erroneous RMP parameter. The following example will generate the RANGE ERROR message shown in Figure 3-2.
AMP = 300 (when programmed to the 270 RNG.)

FIGURE 3-2

ERROR MESSAGES

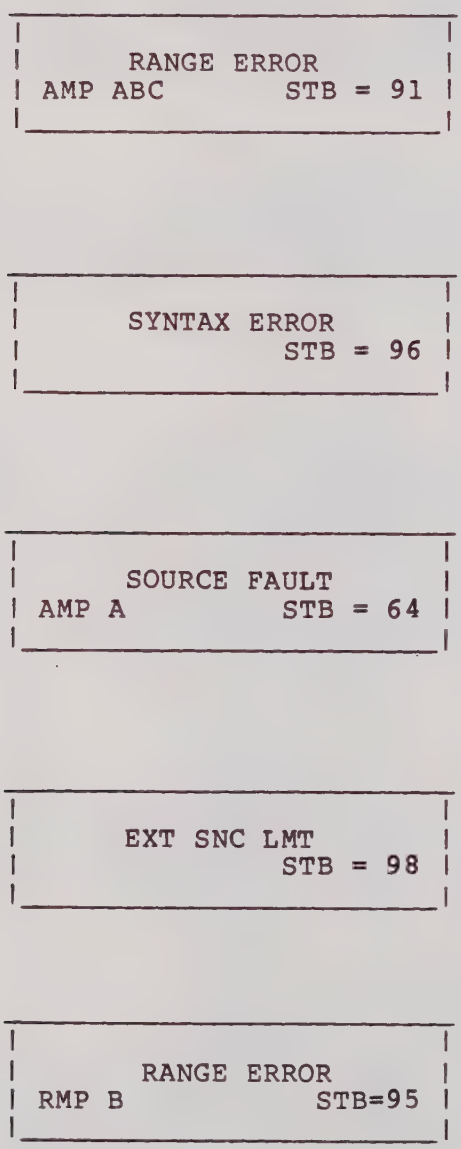


TABLE 3-1
KEYBOARD KEY DESCRIPTIONS

KEY	SCREEN	DESCRIPTION
0 through 9 and .	AMP, FRQ, CRL, PHZ, RNG, CAL	Sets the numeric value for the output parameter identified by parameter screen. Selects status bytes 80 through 89 for keys 0 through 9. Selects registers 0 through 9.
SNW, SQW	WVF	Sets the A,B, or C output to Sine wave (SNW) or Square wave (SQW)
INT, EXT	SNC	Selects the External (EXT) sync. input or Internal (INT) operation.
INT, EXT	CLK	Selects the External (EXT) clock and lock input or Internal (INT) operation.
MNU		Selects the Menu (MNU) screens for all parameter screens. Will not show CAL, CFG, ALM, FLM or ADC screens.
A, B, C	AMP, CRL PHZ, RNG CAL, WVF	Selects the A, B or C function to program the parameter identified by the displayed parameter screen.
A, B, C	CFG	A (LSN) selects Listen Address, B (CFB) selects the configuration byte C (PHZ) selects phase C Initialization Phase.
A, B, C	ALM	A (RNG) selects the voltage range pair and the initial range, B (LLM) displays the value for the low range, C (HLM) displays value for the high range.
A, B, C	FLM	A (FRQ) displays the initial frequency, B (LLM) displays the low frequency limit and C (HLM) displays the high frequency limit.
A, B, C	RMP (A)	A (DLY) selects the step delay time in seconds, B (STP) selects the step size in units related to the ramp parameter, C (VAL) selects the final value.
B, C	RMP (B)	B (STP) selects the step size of the dependant parameter, C (VAL) selects the final step value for step function of dependant parameter.

TABLE 3-1 (CONT.)
KEYBOARD KEY DESCRIPTIONS

REG		Load program register
REC		Recall program register
CLR/SRQ		Generate GPIB Service Request, Clear
MON		Display output value
PRG		Enter a value to be programmed
ENT		Enter Parameter Program (PRG) values

3.4.2 SYNTAX ERROR MESSAGE

The SYNTAX ERROR message will be generated for any non recognizable mnemonic sent on the IEEE-488 interface. The following string will generate a Syntax Error message:
F,R,4,0,0,

3.4.3 SOURCE FAULT MESSAGE

An Output Fault message will be generated in the event that the output voltage can't be maintained at the programmed value. A short on the phase A output will cause the 949XP to generate the Source Fault message in Figure 3-2.

3.5 LOCAL OPERATION

3.5.1 MENU SCREEN

After power-up or GPIB device clear (DCL), the menu #2 screen will be displayed. This screen will show the assigned numeric value for AMP, FRQ, PHZ, and CRL* as 5, 6, 7 and 8 respectively. Depressing the MNU key will cause the menu #3 screen to be displayed with RMP A, RMP B and ELT with equivalent values of 9, 10 and 11 respectively. Depressing the MNU key again will cause menu #4 screen to be displayed with VLT, CUR, PWR and PWF with values of 16, 17, 18 and 19. Depressing the MNU key a third time after power-up will cause the menu #5 screen to be displayed with VLT*, CUR*, and PWR* equal to values 21, 22 and 23 for Meter Module display functions.

Depressing the MNU key a fourth time will cause the menu #1 screen to be displayed with SNC, CLK*, WVF* and RNG equal to values 1, 2, 3 and 4 respectively.

Subsequent depressions of the MNU key will cause the cycle described above to be repeated. Refer to Figure 3-4 for all menu screen displays.

Any parameter screen (ex. FRQ) described in the menu screen will show the programmed value for that parameter and will allow that parameter to be changed while viewing the screen. To display a parameter screen, enter the screen number followed by the ENT key.

The following example illustrates the procedure to select the AMP (voltage) screen:

5,ENT

*These screens will not be displayed if the 949XP and associated power sources do not have compatible hardware.

NOTE

Parameters and outputs not enabled by the Configuration of the 949XP will not be displayed in the menu screens or parameter screens.

3.5.2 PARAMETER SCREENS

To program any 949XP output parameter from the Local program mode the parameter screen must first be selected. Refer to Figure 3-5 for the parameter screens.

Any parameter screen may be selected while any other screen is displayed (except SNC, CLK or WVF) by entering the one or two digit screen number followed by depressing the ENT key.

The following example will select the ELT screen from any screen except SNC, CLK or WVF.
1,0,ENT

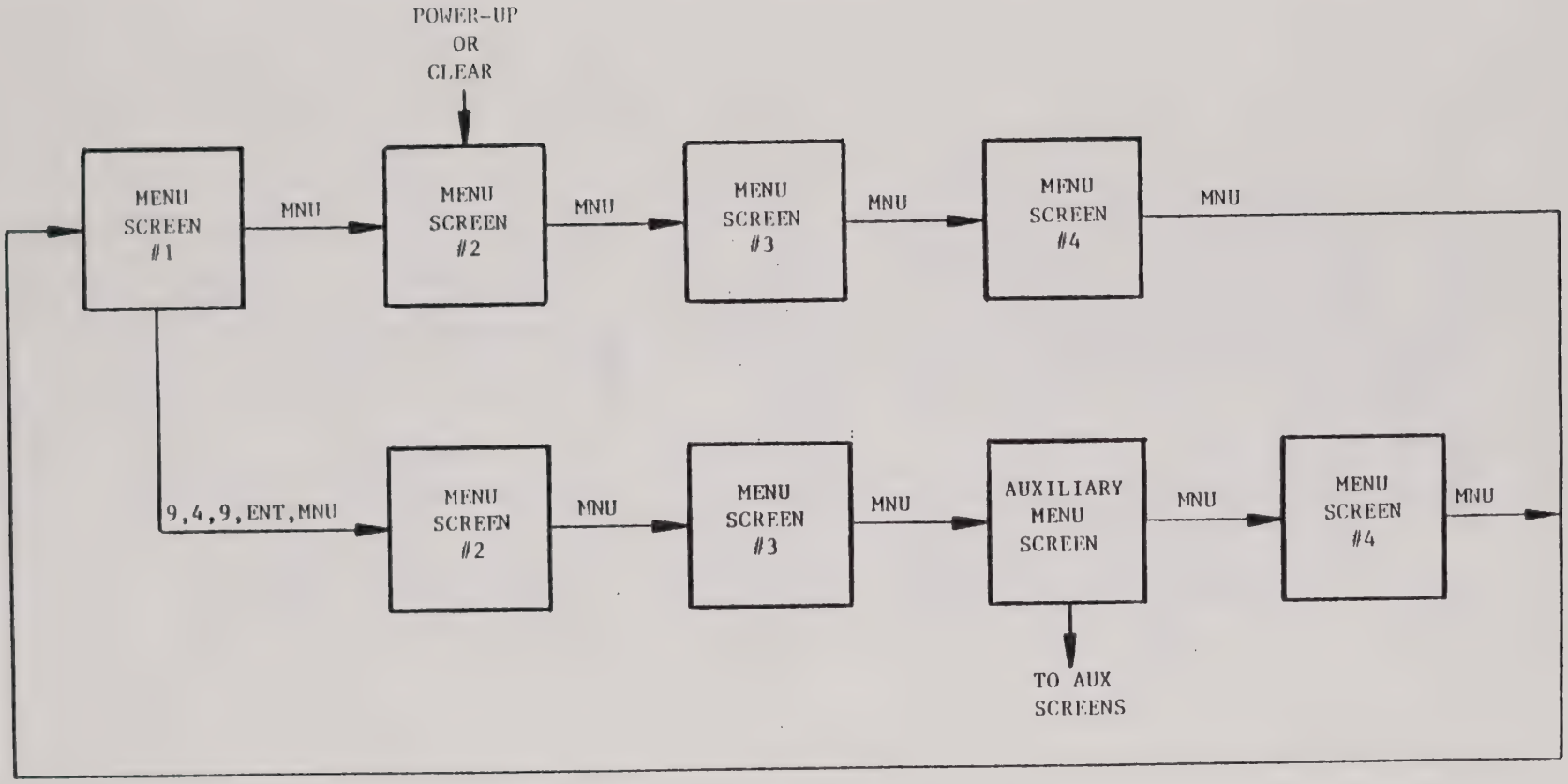
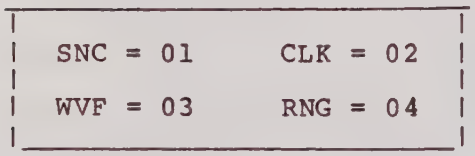


FIGURE 3-3
MENU SCREEN SEQUENCE

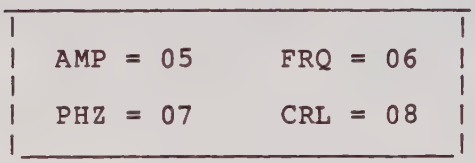
FIGURE 3-4

MENU SCREENS

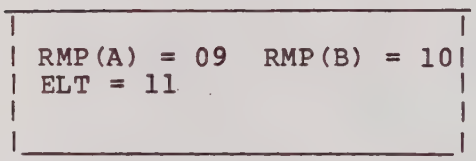
MENU #1 SCREEN



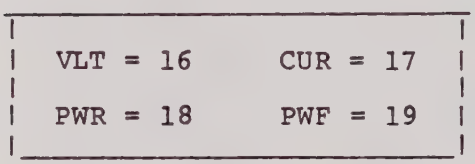
MENU #2 SCREEN



MENU #3 SCREEN



MENU #4 SCREEN



MENU #5 SCREEN

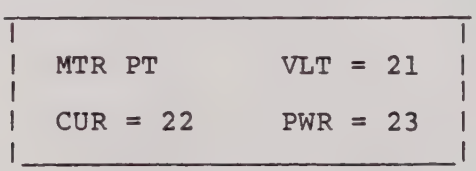
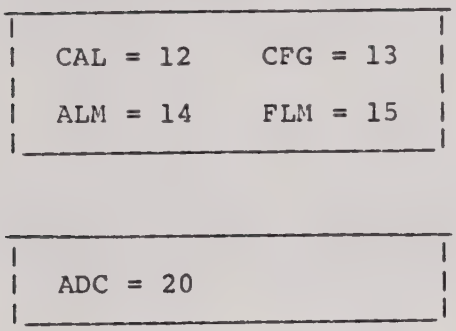


FIGURE 3-4 (CONT.)

AUXILIARY MENU SCREEN



While viewing any of the first eight screens (1 through 11) the screen may be sequenced in ascending order by depressing the MON key or descending order by the PRG key.

While viewing the AMP screen depressing the MON will cause the FRQ screen to be displayed. While viewing the FRQ screen depressing the PRG key will cause the AMP screen to be displayed.

3.5.2.1 SYNCHRONIZE SCREEN (SNC = 01)

The SNC screen displays whether the external or internal SNC mode of operation has been selected. While viewing this screen to select the external SNC mode depress the EXT key or any odd numeric key followed by the PRG and ENT key:

Example: EXT,PRG,ENT

While operating in the EXT SNC mode the FRQ screen will display the frequency of the External Sync. signal. The signal must be between the low frequency limit and 450 Hz or the High Frequency Limit.

NOTE

When viewing the SNC, CLK or WVF screens the MON or PRG keys must be used to sequence to the desired screen. The MNU key can also be used to return to the menu then followed by any screen selection.

To return to the internal SNC mode of operation depress the INT key or any even numeric key followed by the PRG and ENT key while viewing the SNC screen.

Example: INT,PRG,ENT

If the External Sync. signal is not between the Low Frequency Limit and 450 Hz, or the High Frequency Limit, an error message will be displayed. See Figure 3-2. In addition, the 949XP will return to the INT mode of operations.

FIGURE 3-5

PARAMETER SCREENS

SCREEN (#)	
SNC (01)	SNC MON A = INT B = INT C = INT
CLK (02)	CLK MON A = INT B = INT C = INT
WVF (03)	WVF MON A = SNW B = SNW C = SNW
RNG (04)	RNG MON A = 135.0 B = 135.0 C = 135.0
AMP (05)	AMP MON A = 5.0 B = 5.0 C = 5.0
FRG (06)	FRQ MON A = 60.00 B = 60.00 C = 60.00
PHZ (07)	PHZ MON A = 90.0 B = 240.0 C = 120.0
CRL (08)	CRL MON A = 10.0 B = 10.0 C = 10.0

FIGURE 3-5 (CONTINUED)

PARAMETER SCREENS

SCREEN (#)

RMP (A) (09)

```
+-----------------------------------+
|                                   |
|  RMP (A) "1"   A = DLY            |
|                                   |
|  B = STP       C = VAL            |
+-----------------------------------+
```

RMP (B) (10)

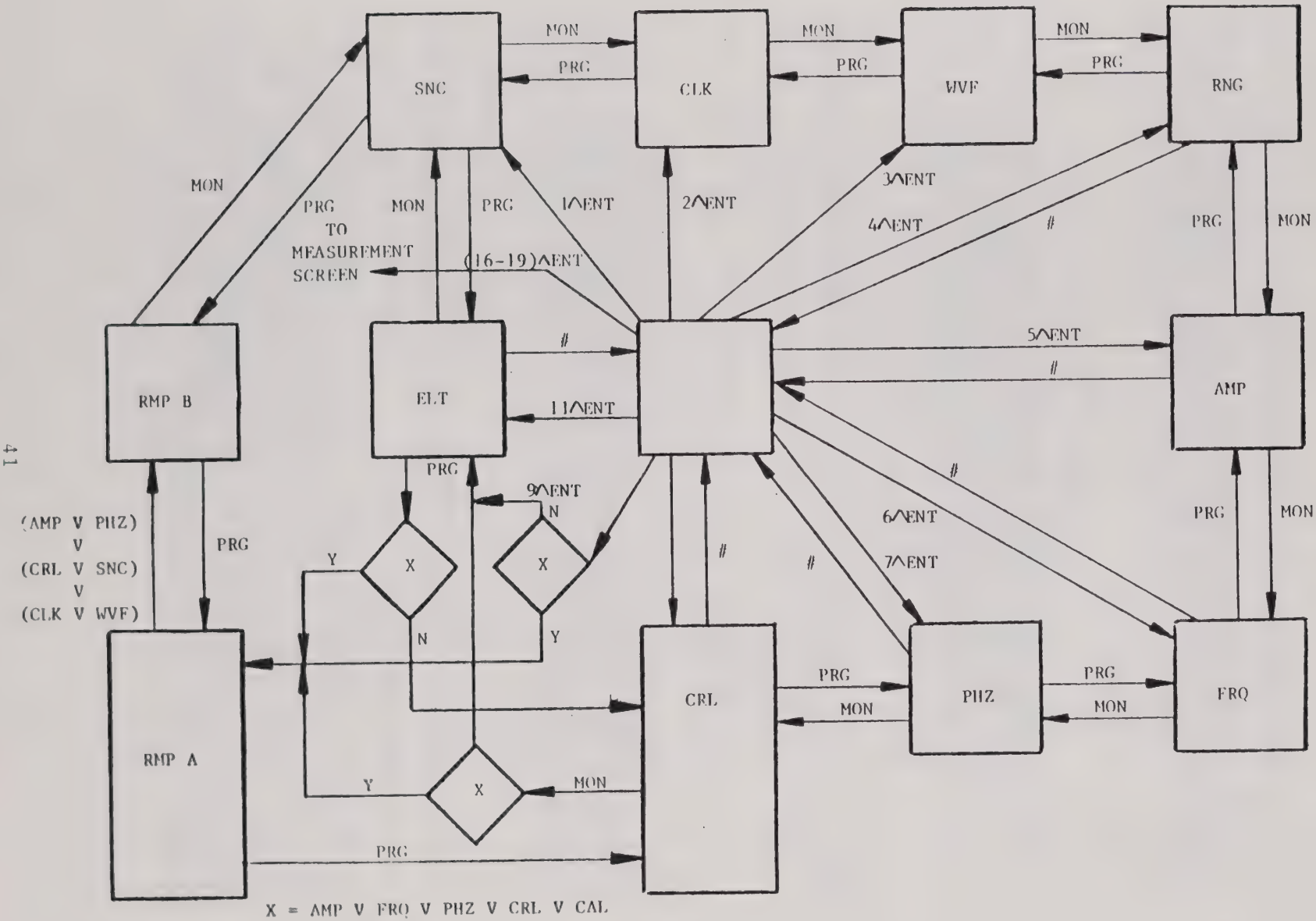
```
+-----------------------------------+
|                                   |
|  RMP (B) "2"                      |
|                                   |
|  B = STP       C = VAL            |
+-----------------------------------+
```

ELT (11)

```
+-----------------------------------+
|                                   |
|  ELT MON       H =                |
|                                   |
|  M =           S =                |
+-----------------------------------+
```

"1" Independent Parameter can be AMP, FRQ, PHZ, CRL or CAL.

"2" Dependant Parameter can be AMP, PHZ, CRL.



^ = AND
V = OR
# = NUMERIC (0 THRU 19)

FIGURE 3-6

PARAMETER SCREEN SEQUENCE

3.5.2.2. CLOCK SCREEN (CLK = 02) (Option)

The CLK screen displays whether the 949XP is operating in the external (EXT) or internal (INT) CLK mode of operation. While viewing this screen to select the EXT CLK mode depress the EXT key or any odd numeric key followed by the PRG and ENT key:

Example: EXT,PRG,ENT

NOTE

Before selecting the External Clock mode ensure that the power source containing the 949XP has the proper clock and lock signals applied to the BNC connectors at the rear panel. Failure to have the proper clock and lock signals when the EXT CLK mode of operation is selected may result in damage to the power source.

To return to the internal (INT) CLK mode of operation depress the INT or any even numeric key followed by the PRG and ENT key while viewing the CLK screen.

Example: INT,PRG,ENT

3.5.2.3 WAVEFORM SCREEN (WVF = 03) (Option)

The WVF screen displays the type of waveform selected, sine wave (SNW) or square wave (SQW), for each of the three outputs. To program a square wave, depress the SQW or any odd number key followed by any combination of the A, B or C key, the PRG key and ENT key. If no phase key is depressed, the new waveform will be programmed for all outputs.

To program phase A and C to square wave: 3,ENT,SQW,A,C,PRG,ENT

To select the sine wave waveform for any phase depress the SNW or any even number key followed by the key sequence described above.

3.5.2.4 RANGE SCREEN (RNG = 04)

The RNG screen has two purposes; to select a range defined by the range pair selected in the amplitude limit (ALM) screen and to set an upper voltage limit less than that specified by the ALM screen, LLM or HLM values. If the range pair 135/270 has been selected in the ALM screen with LLM=135 and HLM=270 , the 135 range of the power source will be programmed by the RNG screen for any value of 135 or less. The value programmed will then be the maximum value allowed to be programmed in the Amplitude (AMP) screen.

Example to select the 270 V range.

4,ENT,2,7,0,PRG,ENT

The RNG value must be entered before the AMP value in an entry sequence (before depressing the ENT key) containing both parameters.

3.5.2.5 VOLTAGE AMPLITUDE SCREEN (AMP = 05)

The AMP screen displays the amplitude value programmed for phase A, B and C. To program a new value, within the limit defined by the ALM screen, depress the numeric key sequence for the desired program value followed by any combination of the phase keys, the PRG and ENT key. If no phase key is depressed the new AMP value will be common to all outputs.

Example to program all outputs to 102.3 volts:

5,ENT,1,0,2,.,3,PRG,ENT

Example to program ØA to 204.7, ØB to 200 and ØC to 190.3 (Must have the 270 RNG selected).

5,ENT,1,9,0,.,3,C,PRG,2,0,0,B,PRG,2,0,4,.,7,A,PRG,ENT

3.5.2.6 FREQUENCY SCREEN (FRQ = 06)

The FRQ screen displays the programmed frequency in Hertz for all operating modes except External CLK. In the EXT SNC mode the FRQ screen displays the actual frequency of the External sync. signal. While displaying the FRQ screen, any frequency from the low limit (LLM) to the high limit (HLM) may be programmed.

Example to program 60.57 Hz:

6,ENT,6,0,.,5,7,PRG,ENT

Example to program 5100 Hz:

6,ENT,5,1,0,0,PRG,ENT

3.5.2.7 PHASE SCREEN (PHZ = 07)

The phase screen displays the phase angle in degrees of the B and C outputs leading the A output.

In the EXT CLK mode the A value represents the angle of the A output leading the A output of the master 949XP controller.

In the EXT SNC mode the A value represents the angle of the A output leading the External Sync. TTL input. This angle should not be programmed closer than 20 degrees to any zero crossing of the waveform (20 degrees<A<160 degrees, 200 degrees<A<340 degrees etc.).

Example to program øB to 45.3 degrees:

7,ENT,4,5,.,3,B,PRG,ENT

Example to program øB to 90 degrees and øC to 180 degrees:

7,ENT,9,0,B,PRG,1,8,0,C,PRG,ENT

3.5.2.8 CURRENT LIMIT SCREEN (CRL = 08) (Option)

The CRL screen displays the Current Limit value in amps.

The programmable current limit feature must be used with a power source that incorporates the current limit feature.

Example to program current limit on all phases to 100 amps:

8,ENT,1,0,0,PRG,ENT

Example to program output A to 50 amps limit:

8,ENT,5,0,A,PRG,ENT

If the 949XP is used with a power source not compatible with current limit programming the CRL screen will not be displayed. The current limit will then be fixed by the power source at its maximum current capacity.

3.5.2.9 RAMP SCREENS

3.5.2.9.1 RAMP A SCREEN (RMP A = 09)

The RMP A screen allows any programmable parameter (AMP, FRQ, PHZ CAL or CRL) to be Stepped (STP) with a Delay (DLY) for each step to a final value (VAL).

There are two types of programs that may be specified by the RMP screen a step and a ramp.

The step program will program the output parameter value specified by a previous screen for the time specified for the DLY value in seconds. The parameter will then return to a final value specified by the VAL value.

The ramp program will step the output parameter value specified by a previous screen with the STP value, the DLY time per step and the final VAL setup in the RMP A screen. The ramp will increment if the VAL value is larger than the parameter value. It will decrement if it is less than the parameter value.

NOTE

> The DLY, STP or VAL parameters must be specified (A,B or C key depressed) before the numeric value for the parameter is entered.

When ramping frequency, an error message will result with an attempt to step the frequency with greater resolution than that possible by the initial or final values. The frequency resolution is four decades.

The following is an example to program 130V for 2.5 seconds and then return to a final value of 115V.

First select the AMP screen and program 130V:

5,ENT,1,3,0,PRG*

Next select the RMP A screen, program a DLY of 2.5, a final VAL of 115 and run the program:

9,ENT,A,2,.,5,PRG,C,1,1,5,PRG,ENT

The following is an example to program 400 Hz with the B and C phase fixed while the A phase ramps from 10V to 110V in 1 volt steps each step lasting .5 seconds:

6,ENT,4,0,0,PRG,5,ENT,1,0,A,PRG,9,ENT,A,0,.,5,PRG,B,1,PRG,C,1,1,
0,PRG,ENT

The preceding example illustrates that all fixed output parameters may be setup in a Ramp. This may also be accomplished in a step.

The parameter screen immediately preceding the selection of the RMP A screen will be the parameter operated on by the Ramp function.

To enter DLY or STP values less than 1 the number 0 must precede the decimal point.

The ramp may be terminated at any time by depressing the ENT key.

*If the ENT key is depressed at this point the AMP would be programmed to and remain at 130 volts.

3.5.2.9.2 RAMP B SCREEN (RMP B=10)

The RMP B screen allows two parameters to be ramped simultaneously. The parameter programmed just prior to entering the RMP A screen, will be the independent parameter and will be identified in that screen. The parameter loaded prior to the independent parameter will be the dependent parameter.

NOTE

When ramping the FRQ parameter with any other, it must be the independent parameter. When AMP is ramped with any other parameter other than FRQ, it must be independent for the best DLY accuracy.

The following example will ramp frequency from 360 to 440 Hz at a rate of .2 Hz per .2 second, while each .2 Hz step causes the amplitude to go from 10 volts to 210 volts in .5 volt steps.

5,ENT,1,0,PRG,6,ENT,3,6,0,PRG,9,ENT,A,0,.,2,PRG,B,0,.,2,PRG,C,4,4,
0,PRG,1,0,ENT,B,0,.,5,PRG,ENT

The final value of the dependent parameter, AMP, will be determined by the number of steps of the independent parameter and the STP value, .5V, specified in RMP B.

FINAL VALUE = INITIAL VALUE + RMP B STP * NO. STEPS
NO. STEPS = DEP. PAR. (FINAL VALUE - INITIAL VALUE)/STEP SIZE

In this example:

NO. STEPS = (440 - 360)/.2 = 400

FINAL AMP VALUE = 10 + .5 X 400 = 210 Volts

If the final value exceeds the RNG value, an error message will be generated.

The following example will simultaneously program the output frequency to 400 Hz, the waveform to squarewave and the amplitude to 130 volts for 2 seconds before returning to a 115 volts sine wave.

6ENT4,0,0,PRG,3,ENT,SQW,PRG,MON,MON,1,3,0,PRG,9,ENT,A,2,PRG,C,
1,1,5,PRG,MON,C,SNW,PRG,ENT

3.5.2.10 ELAPSED TIME SCREEN (ELT = 11)

This screen displays the total run time accumulated on the 949XP.

H = Hours

M = Minutes

S = Seconds

3.5.2.11 INSTRUMENT MODULE POINTER SELECTION

Figure 3-4 shows there is a Menu screen #5 with three additional selections; VLT(21), CUR(22) and PWR(23).

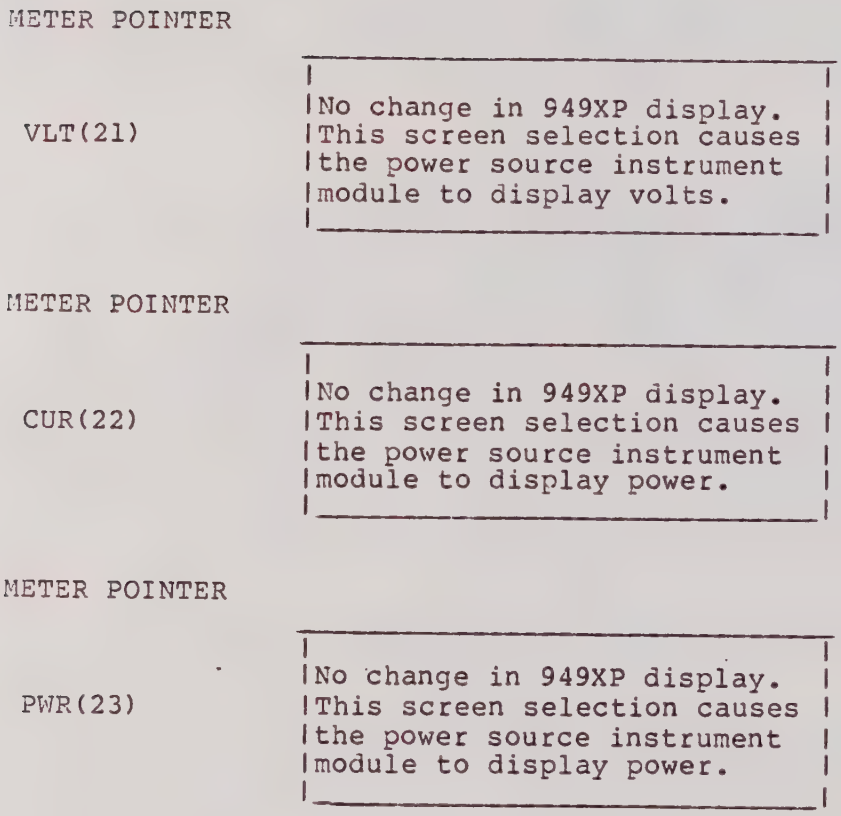
These three selections will not alter the 949XP display. They will instead cause the power source instrument module to display either volts for selection VLT(21), current for selection CUR(22) or power for selection PWR(23).

The following example will allow the instrument module to display volts on its LED display:

2,1,ENT

FIGURE 3-7

METER MODULE POINTER


METER POINTER
VLT(21)
No change in 949XP display. This screen selection causes the power source instrument module to display volts.
METER POINTER
CUR(22)
No change in 949XP display. This screen selection causes the power source instrument module to display power.
METER POINTER
PWR(23)
No change in 949XP display. This screen selection causes the power source instrument module to display power.

3.5.3 MEASUREMENT SCREENS

Each of the four measurement screens for voltage, current, power and power factor display the phase A, B and C outputs simultaneously. Refer to Figure 3-8. To exit any measurement screen, it may be necessary to hold the first numeric key longer than usual.

3.5.3.1 VOLTAGE SCREEN (VLT=16)

The voltage screen displays the output voltage with 0.1 volts resolution. This voltage is the voltage at the power source J2 connector for each phase.

3.5.3.2 CURRENT SCREEN (CUR=17)

The current screen displays the output current in amps.

3.5.3.3 POWER SCREEN (PWR=18)

This screen displays the power source output power in kilowatts. It displays Watts when used with the IMC3 and 153XP Power Source.

3.5.3.4 POWER FACTOR (PWF=19)

This screen displays the power factor to 1.000 with 0.001 resolution. The PWF screen will read unity for loads less than 0.1 amp. When this screen is displayed after another screen, it takes approximately two seconds to update the screen.

FIGURE 3-8

MEASUREMENT SCREENS

VLT (16)

```
VLT MON      A=nnn.n
B=nnn.n      C=nnn.n
```

CUR (n)

```
CUR MON      A=nn.nn
B=nn.nn      C=nn.nn
```

PWR (18)

```
PWR MON      A=n.nnn
B=n.nnn      C=n.nnn
```

PWF (19

```
PWF MON      A=n.nnn
B=n.nnn      C=n.nnn
```

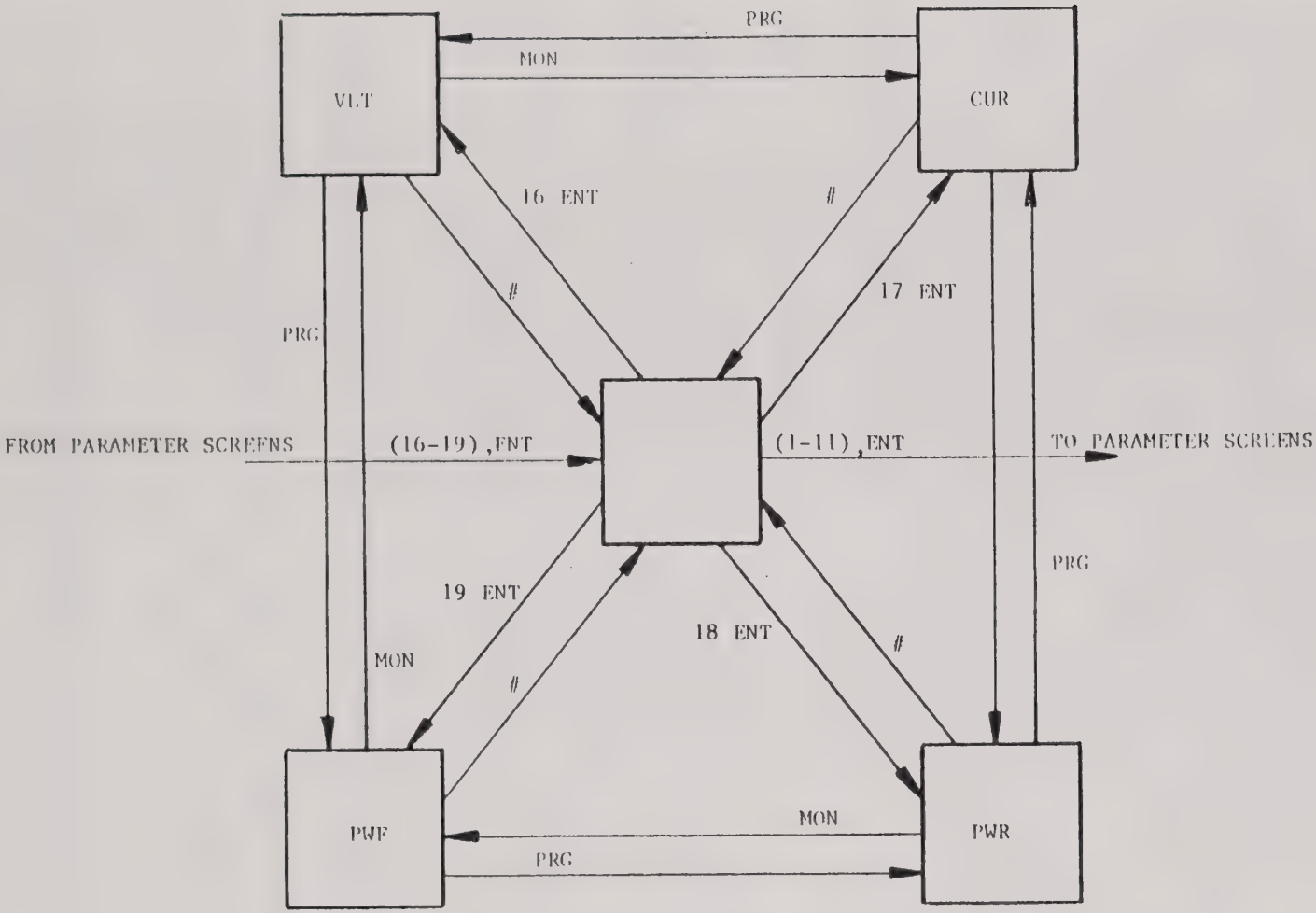


FIGURE 3-9
MEASUREMENT SCREENS SEQUENCE

FIGURE 3-10

AUXILIARY SCREENS

SCREEN (#)

CAL (12)

```
CAL MON        A =
B =            C =
```

CFG (13)

```
CFG MON        A = LSN
B = CFB        C = PHZ
```

ALM (14)

```
ALM MON        A = RNG
B = LLM        C = HLM
```

FLM (15)

```
FLM MON        A = FRQ
B = LLM        C = HLM
```

3.5.4 AUXILIARY SCREENS

There are four auxiliary screens not shown on any page of the Menu Screen without first entering a special key sequence. They can be used to change the Calibration (CAL) and Unit Address (LSN). The parameters for voltage range pair (RNG), Low Frequency Limit (LLM), High Frequency Limit (HLM), Initial Frequency (FRQ), the Phase Configuration (PHZ), the amplitude limit for the low voltage range (LLM) and the amplitude limit for the high voltage range (HLM) can be displayed only.

Figure 3-10 shows the special screens and their related selection numbers. To select the auxiliary screens, first select menu screen #1. Enter the numeric code 949 then ENT. Depress the MNU key three times to display the Auxiliary screens. Enter the screen number desired followed by depressing the ENT key.

All values displayed in the auxiliary screens are stored in Nonvolitile RAM (NVRAM).

3.5.4.1 CALIBRATION SCREEN (CAL=12)

The calibration screen displays the calibration coefficient assigned to each of the three outputs. The calibration coefficient is a relative value from 0 to 255. The calibration coefficient range will vary the output ±1.24% from the nominal calibration point.

Each increment of the coefficient changes the output by .01% of the output if the calibration voltage is 135.0 (used for the 135 RNG). Each step represents approx. .01 volts. Each step is .02 volts for the 270.0 calibration point. During the calibration mode the calibration coefficient can be incremented or decremented from any starting value.

For example, if the calibration coefficient for an output is 0 and the output is .5 volts low at 135.0, start the calibration at approximately 40.

Example to calibrate the A output at 135.0 volts starting with a calibration coefficient of 40 with 1 second per step:

First program the output to 135 volts (First follow procedure in paragraph 3.5.4) then:

5,ENT,1,3,5,PRG,ENT

Next enable the selection of the auxiliary screens as described in paragraph 3.5.4, select the CAL screen and enter the starting point for phase A:

1,2,ENT,4,0,A,PRG

Next select the RMP A screen and start the calibration ramp:

9,ENT,A,2,PRG,ENT

Depress the ENT key when the output voltage reaches the programmed voltage.

3.5.4.2 CONFIGURATION SCREEN (CFG = 13)

The CFG screen shows three parameters identified by the A, B and C designators.

3.5.4.2.1 UNIT ADDRESS (LSN)

Depressing the A key shows the IEEE-488 Unit Address (LSN). Any value from 0 through 30 may be entered for the equivalent Unit Address.

Example to set the Listen address to 16 (first follow prcedure in paragraph 3.5.4) then:

A,1,6,PRG,ENT

3.5.4.2.2 CONFIGURATION BYTE (CFB)

Depressing the B key shows the 949XP Configuration Byte. This byte is a numeric value from 0 to 255 that describes the hardware options with which the 949XP is configured.

CFB Weight	128	64	32	16	8	4	2	1
Function	PWR	CUR	VLT	CRL	PHZ	FRQ	WVF	CLK

With CLK enabled, the power source must have the CLOCK and LOCK hardware in place.

With WVF enabled, the power source must be characterized for square wave operation.

With FRQ enabled, the 949XP will allow the frequency to be programmed. With FRQ disabled, the FRQ will remain at its initial frequency.

With PHZ enabled, the 949XP will allow phase programming. Disabled, the phase will remain at its initial configuration value(s).

With CRL enabled, the power source and 949XP must have the current limit option.

With VLT or CUR enabled, the 949XP must have the Measurement option. The power source must have the IMC Instrument Modules.

With PWR enabled, the 949XP must have the Measurement option: The power source must have the IMC instrument module.

With the PWR option, the CUR and VLT options are included.

The CUR and VLT options are supplied together.

The CFB=110 enables WVF, FRQ, PHZ, VLT and CUR.

The CFB=238 enables WVF, FRQ, PHZ, VLT, CUR and PWR.

3.5.4.2.3 PHASE C INITIAL VALUE (PHZ)

Depressing the C key shows the Phase (PHZ) initial value. Any value may be displayed for this parameter but 0 indicates that a single phase power source is being used and 120 indicates a three phase power system has been configured. Any value except 0 or 120 will be interpreted as a two phase system using the A and C outputs. The 949XP CPU will enable the appropriate amplitude fault interrupt based on the number of phases it has identified by the PHZ value.

3.5.4.3 AMPLITUDE LIMIT SCREEN (ALM = 14)

Like the CFG screen the ALM screen uses the A, B and C designators to identify three parameters.

The A value is the range pair code. To review the value depress the A key. The B value (LLM) is the limit for the low voltage range. The C value (HLM) is the limit for the high voltage range.

3.5.4.3.1 RANGE PAIRS (RNG)

Depressing the A key shows the voltage Range (RNG) pair code identified in Table 3-2. Each range pair has a complement code that will allow the 949XP to initialize on the opposite range.

TABLE 3-2

RANGE PAIR CODES

RNG #	RANGE PAIR	INITIAL RANGE
0	200.0/400.0	LLM
1	20.00/40.00	LLM
2	20.00/200.0	LLM
3	20.00/400.0	LLM
4	40.00/200.0	LLM
5	40.00/400.0	LLM
8	400.0/200.0	HLM
9	40.00/20.00	HLM
10	200.0/20.00	HLM
11	400.0/40.00	HLM
12	200.0/40.00	HLM
13	400.0/40.00	HLM

3.5.4.3.2 LOW LIMIT (LLM)*

Depressing the B key shows the value of the lowest voltage range of the range pair. The range for this parameter is any value from zero to the lowest value defined by the range pair code.

Example to define the 135.0/270.0 with initialization on the 135V range.

ALM screen values:

RNG = 0
LLM = 135.0
HLM = 270.0

3.5.4.3.3 HIGH LIMIT (HLM)*

Depressing the C key shows the value of the highest voltage range of the range pair. The range for this parameter is any value from zero to the highest value defined by the range pair.

Example to define the 270.0/135.0 with initialization on the 270V range.

ALM screen values:

RNG = 8
LLM = 135.0
HLM = 270.0

3.5.4.4 FREQUENCY LIMIT SCREEN (FLM=15)

The A, B and C designators identify the FRQ, LLM and HLM parameters respectively.

3.5.4.4.1 INITIAL FREQUENCY (FRQ)

Depressing the A key shows the 949XP power-up frequency.

3.5.4.4.2 LOW FREQUENCY LIMIT (LLM)

Depressing the B key shows the Low Frequency Limit (LLM) value.

3.5.4.4.3 HIGH FREQUENCY LIMIT (HLM)

Depressing the C key shows the High Frequency Limit (HLM).

3.5.5 SPECIAL PURPOSE KEYS

There are three keys on the 949XP that serve a purpose other than the programming of output parameters; the REG, REC and CLR/SRQ keys.

3.5.5.1 REG (REGISTER) KEY

The 949XP has 10 registers 0 through 9 that are available to store any mixture of the output parameters WVF, RNG, AMP, FRQ, PHZ, CRL and RMP. The A, B and C outputs may each have different values for each parameter.

A parameter not specified in a register will assume the existing operating parameter when the register is recalled.

This example will store the following parameters into register 9:

```
WVF A,B,C = SNW          FRQ   = 400
PHZ B     = 240          AMP A = 80
PHZ C     = 120          AMP B = 100
                         AMP C = 120
```

3,ENT,SNW,PRG,MON,MON,7,ENT,2,4,0,B,PRG,1,2,0,C,PRG,PRG,4,0,0,PRG, PRG,8,0,A,PRG,1,0,0,B,PRG,1,2,0,C,PRG,9,REG

The display will show the REG mnemonic with the register number after a store operation.

Values stored into register 0 will be stored in non-volatile (NVRAM) and hence will be retained during power down.

3.5.5.2 REC (RECALL) KEY

The recall key is used to recall the output parameters stored in any of the ten registers.

After a recall operation the display will show the REC mnemonic with the register number recalled. An attempt made to recall an empty register will cause the display to indicate a Recall operation but the output parameters will remain unchanged after the ENT key is depressed.

The following example will recall and output all parameters stored in 3.5.5.1

9,REC,ENT

CAUTION

Any parameter not specified in a register will remain unchanged after a Recall operation.

3.5.5.3 CLR/SRQ (CLEAR/SERVICE REQUEST)

The CLR/SRQ key serves two functions. It is used to generate an IEEE-488 (GPIB) Service Request interrupt to Bus Controller. During a subsequent serial poll the 949XP will send a Status Byte (STB) to the controller that is a function of the number key depressed preceding the CLR/SRQ key. The decimal value of the STB will equal the number key plus 80. Ten STB can be generated from the keyboard with values 80 through 89.

The following key sequence example will generate an SRQ with a Status Byte of 80:

0,SRQ

The second function of the CLR/SRQ is that of a Clear key. During the programming of parameters the setup data may be cleared by depressing the CLR/SRQ key. This is a safety precaution to ensure that no data will be changed if the ENT key is depressed.

All numeric data entered on the display screen prior to depressing the PRG key will be cleared by depressing the CLR/SRQ key once. After the PRG key has been depressed, two depressions of the CLR/SRQ are required. Depressing the key three times will clear set-up parameters in other screens.

If the following key sequence is followed 5,ENT,1,3,5,PRG, the output will be 135 volts after the ENT key is depressed.

Depressing the CLR/SRQ key twice will clear the setup data and prevent the existing output parameters from changing if the ENT key is depressed.

3.5.5.4 SIMULTANEOUS PARAMETER ENTRY

The parameters SNC, CLK, WVF, RNG, AMP, FRQ, PHZ, CRL and RMP may all be entered simultaneously.

The following example will change all parameters except SNC and CLK with the same entry sequence. In addition the C output will ramp from 0 degrees to 720 degrees in .5 degrees/.5 sec. steps.

NOTE

For simplicity the following example uses the notation ( ) to enclose the desired parameter screen instead of the actual key sequence.

(WVF), SNW,PRG,(RNG),1,3,0,PRG,(FRQ),4,0,0,PRG,(AMP),1,0,0,PRG, (PHZ),2,4,0,B,PRG,0,C,PRG,(RMP),A,0,.,5,PRG,B,0,.,5,PRG,C,7,2, 0,PRG

NOTE

For simultaneous parameter entry of RNG and AMP the entry sequency must have the RNG parameter precede the AMP parameter or a syntax error will be generated.

The parameter change will occur whenever the ENT key is depressed. The parameters may be reviewed before depressing the ENT key by sequencing through the screens with the PRG key. When the program parameters are correct, depress the ENT key to change the parameters and start the ramp.

3.6 REMOTE OPERATION

Remote programming for the 949XP IEEE-488 GPIB interface consists of sending the unit address and the proper ASCII alphanumeric characters to identify the parameter and the numerical value or other argument. The description of the abbreviations for GPIB messages used in this section are listed in Table 3-3.

These abbreviations must not be confused with the device dependent abbreviations used to describe the 949XP operating parameters (ex. FRQ = Frequency etc.)

3.6.1 UNIT ADDRESS

This is the A value (LSN) set in the CFG screen (Ref. 3.5.4.2.1). The Unit Address 0 through 30 corresponds to the HEX value 20 through 3E. Refer to Table 3-4 for the equivalent HEX, Binary, ASCII and Decimal equivalents. The Unit Address is set at the factory to 1.

TABLE 3-3

COMMONLY USED GPIB ABBREVIATIONS

ABBREVIATION	DEFINITION
ATN	Attention. A logic line on the GPIB asserted only by the controller to indicate the data on the bus represents a bus message.
CR	An ASCII carriage return.
DCL	Device Clear. A universal bus message to initialize all instruments to their power-on states.
END	End. A message conveyed when a talker uses the EOI line with the last data byte of a data string.
EOI	End Or identify. A logic line on the GPIB asserted by a talker to indicate the last byte of a data string.
EOS	End Of String. A delimiter message that consists of a data byte(s) to indicate the end of a data string.
GET	Group Execute Trigger. A GPIB message to trigger an addressed instrument.
GTL	Go To Local. A GPIB message to put an addressed instrument in the local control mode.
IFC	Interface Clear. A logic line on the GPIB asserted by the controller to clear all interfaces (ex., default to unlisten and untalk).
LF	An ASCII line feed.
REN	Remote Enable. A logic line on the GPIB asserted by the controller. REN enables an instrument to go to local when addressed.
SDC	Selected Device Clear. A GPIB message to initialize an addressed instrument to its Power-on state.

TABLE 3-4

UNIT ADDRESS GROUP

LISTEN ADDRESS	HEX	BINARY	A5	A4	A3	A2	A1	DECIMAL	ASCII
0	20	001	0	0	0	0	0	32	SP
1	21	001	0	0	0	0	1	33	!
2	22	001	0	0	0	1	0	34	"
3	23	001	0	0	0	1	1	35	#
4	24	001	0	0	1	0	0	36	$
5	25	001	0	0	1	0	1	37	%
6	26	001	0	0	1	1	0	38	&
7	27	001	0	0	1	1	1	39	'
8	28	001	0	1	0	0	0	40	(
9	29	001	0	1	0	0	1	41	)
10	2A	001	0	1	0	1	0	42	*
11	2B	001	0	1	0	1	1	43	+
12	2C	001	0	1	1	0	0	44	,
13	2D	001	0	1	1	0	1	45	-
14	2E	001	0	1	1	1	0	46	.
15	2F	001	0	1	1	1	1	47	/
16	30	001	1	0	0	0	0	48	0
17	31	001	1	0	0	0	1	49	1
18	32	001	1	0	0	1	0	50	2
19	33	001	1	0	0	1	1	51	3
20	34	001	1	0	1	0	0	52	4
21	35	001	1	0	1	0	1	53	5
22	36	001	1	0	1	1	0	54	6
23	37	001	1	0	1	1	1	55	7
24	38	001	1	1	0	0	0	56	8
25	39	001	1	1	0	0	1	57	9
26	3A	001	1	1	0	1	0	58	:
27	3B	001	1	1	0	1	1	59	;
28	3C	001	1	1	1	0	0	60	<
29	3D	001	1	1	1	0	1	61	=
30	3E	001	1	1	1	1	0	62	>
UNL	3F	001	1	1	1	1	1	63	?

3.6.2 MESSAGE FORMAT

The message sent to the 949XP must have the following format for each parameter:

HHHDXXX----------------E±NND

where

H = Three letter mnemonic for each message header
D = Optional header extension to specify output (ref. table 3-5)
X = Alpha, numeric argument or # for message header argument.
E = Optional ASCII E for exponent identification
± = Exponent sign
N = Exponent value 0 to ±63
D = Message string delimiter. (CR) (LF) standard

More than one message header with its corresponding argument may be sent in one setup string with a common delimiter.

The ASCII # symbol is used in a ramp program to designate that the start of the ramp is the existing output value. This feature is useful when remotely calibrating the 949XP without knowing the existing CAL coefficient.

3.6.2.1 PROGRAM HEADERS

A Program Header is a mnemonic of a series of three ASCII characters used to select an 949XP function or identify the data it precedes. The header is an abbreviation of the program function it identifies.

The header may be folllowed by a header extension to separately program each output to different values. If an extension is not added to the header all outputs will be programmed to the header's argument. See Table 3-5 for the definition of the Program Headers and their related arguments.

Any header that is sent to the 949XP without an argument will cause the front panel display to show the corresponding screen.

The program header extension works on the trailing exception rule. This characteristic can be used to shorten the setup string. The following example demonstrates the trailing exception rule by programming the phase A and B outputs to the square wave waveform and phase C to a sine wave.

WVF SQW WVF C SNW

TABLE 3-5
PROGRAM HEADERS

HEADER	EXTENSION	ARGUMENT	DEFINITION
AMP	A, B, C	# or numeric from 0.0 to RNG value.	Amplitude in volts.
CAL	A, B, C	# or numeric data from 0.0 to 255	Calibration Coefficient
CLK		INT,EXT	Clock source
CRL	A, B, C	# or numeric data from 0.0 to 100.0	Current limit in amps
DLY		Numeric data from 0.00 to 9999	Delay in seconds
FRQ		Numeric data from 45.00 or LLM to HLM value	Frequency in hertz.
PHZ	A, B, C	# or numeric data from 0.0 to ±999.9	Phase angle in degrees.
PRG		0 through 9	Register load
REC		0 through 9	Recall register
REG		0 through 9	Register load
RNG	A, B, C	0.0 to limit value of range	Amplitude range and limit value in volts.
SNC		INT,EXT	Synchronize
SRQ		1 or 0	Service Request enable or disable.

TABLE 3-5 (CONT.)
PROGRAM HEADERS

HEADER	EXTENSION	ARGUMENT	DEFINITION
STP		From parameter minimum to maximum value	Step size
TLK		Any program header or other argument	Set-up 949XP to talk argument when talk addressed.
TRG			Execute (Trigger) set-up parameters on GPIB "GET" message.
VAL		From parameter minimum to maximum value.	Final ramp or step value in volts, hertz, amps, degrees, sine wave or square wave.
WVF	A, B, C	SNW,SQW	Waveform

NOTE: If Extension does not follow the header, the argument will be applied to all phases.

3.6.2.1.1 AMPLITUDE (AMP)

The AMP header with the optional A, B or C extension is used to identify the amplitude command. The argument is a numeric data field from 0.0 to the limit set by the RNG value. An attempt to program a value higher than this value will generate an error and a SRQ on the GPIB. The # symbol may also be used when ramping the AMP parameter.

The following examples represent ASCII strings the 949XP will recognize for various amplitudes:

A,B,C 0.0 volts	AMP0	or	AMPA0AMPB0AMPC0		
A,B,C 10.5 volts	AMP10.5	or	AMP1.05E1	or	AMP105E-1
A,B,C 100 volts	AMP100	or	AMP100.0	or	AMP1E2
A,B = 110.5, C = 115	AMPA110.5AMPB110.5AMPC115 or AMP110.5AMPC115				

3.6.2.1.2 CALIBRATE (CAL)

The CAL header with the required A, B or C extension is used to identify the Calibrate command. The argument is a relative starting coefficient from 0 to 255 or # symbol.

The CAL ramp is terminated with the GPIB message Group Execute Trigger (GET).

The CAL header can be used with a Delay (DLY) command to allow the external calibration AC DVM time to settle. Refer to paragraph 3.5.4.1 for additional information.

A CAL coefficient can be programmed without a ramp by including the VAL header with the same argument as the CAL header.

To program the CAL A coefficient to 55 use the following string:

CALA55 VAL55

To calibrate phase A at 135.0 volts, start the CAL routine with a GPIB GET message with the CAL coefficient starting at 20 and with each step lasting 2 seconds use the following string:

AMP135.0 CALA20 DLY2 TRG

In this example the output will program to 135.0 and start to change the output by stepping the CAL value after a "GET" message. The ramp will terminate after a second "GET" message.

To calibrate phase A at 135 volts and start the ramp with the existing CAL coefficient reducing the output with steps lasting one second:

AMP135.0 CALA# DLY1 VAL0

Again the ramp must be terminated with the bus "GET" message when the external AC calibration DVM indicates the correct voltage.

3.6.2.1.3 CLOCK (CLK)

The CLK header is used to select the clock and lock source for the 949XP. If external clock and lock signals are connected to J5 and J6 at the rear panel of the power source, the signals may be selected by following string:

CLK EXT

The normal or internal (INT) mode of operation for the 949XP is selected by sending:

CLK INT

CAUTION

Failure to have an external clock signal connected to J5 with jumper W3 installed on the 949XP Reference Board when the external clock mode is selected may result in severe damage to the power source.

3.6.2.1.4 CURRENT LIMIT (CRL)

The CRL header with the optional A, B or C extension is used to identify the Current Limit Command. The argument is a numeric data field from 0.0 to 100.0 amps.

The following string will program a current limit of 100 amps for all three phases:

CRL 100

3.6.2.1.5 DELAY (DLY)

The DLY header is used with a parameter that has a numeric argument (ex. AMP, FRQ, PHZ, CRL, CAL) in a single step program.

The STP header with VAL may be used with DLY to completely specify a ramp program.

The following string will first step the voltage to 125 volts for 2.55 seconds and return to 115 volts.

AMP 125 DLY 2.55 VAL 115

The following string will ramp the voltage from 10 volts to 115 volts with 1.5 volt/.5 sec. steps

AMP 10 DLY .5 STP 1.5 VAL 115

3.6.2.1.6 FREQUENCY (FRQ)

The FRQ header is used to identify the following numeric data as frequency.

The following string will program the frequency to 60.56 Hz.

FRQ 60.56

3.6.2.1.7 PHASE (PHZ)

The PHZ header with the optional A, B or C extension is used to identify the following numeric data as phase.

The PHZ header sent with no extension will program the B and C outputs in phase with phase A. The phase of the A output will lead the EXT SNC signal or EXT lock and clock signal by the value programmed.

The following example will program the A, B and C outputs to 90 degrees relative to an external sync. signal when operating in the EXT SNC mode:

PHZ 90

The following example will program the B and C phases to 240.5 degrees and 119.3 degrees respectively leading phase A.

PHZB 240.5 PHZ C 119.3

3.6.2.1.8 REGISTER (REG)

The REG header is used to load the register specified by the following single digit numeric data with the preceding data. The PRG header is identical to the REG header and is included to standardize other AC power controllers with the 949XP.

The following example will load a ramp program that will step the voltage from 10 to 115 volts with 1 volt/.5 sec. steps at 400 Hz into register 0.

```
FRQ 400 AMP 10 DLY .5 STP 1 VAL 115 REG 0
```

Refer to paragraph 3.5.5.1 for additional information.

3.6.2.1.9 RECALL (REC)

The REC header is used to recall previously loaded data from a register identified by the following single digit numeric data.

The following example recalls and outputs the parameters stored in register 0 by the example in paragraph 3.6.2.1.8.

```
REC 0
```

The following example recalls the parameters in register 0 and outputs the parameters after the IEEE-488 "GET" bus message.

```
REC 0 TRG
```

3.6.2.1.10 RANGE (RNG)

The RNG header with the A, B and C extension is used to select a range defined by the ALM screen RNG, LLM and HLM values. The numeric value following the RNG header will also define the upper limit for the AMP value. The RNG value will select the higher range if the value is greater than the lower range value defined by the ALM screen.

If the range and voltage amplitude are to be programmed by the same data string the RNG header and argument must precede the AMP header or a syntax error will be generated.

The following example will select the 270 range from the 135/270 range pair with an upper amplitude limit of 210 volts.

```
RNG 210
```

3.6.2.1.11 SYNCHRONIZE (SNC)

The SNC header is used with the EXT argument to synchronize to an external TTL input. The EXT SNC mode can also be used to program the phase A output at the point on the waveform defined by the PHZ A value.

3.6.2.1.12 SERVICE REQUEST (SRQ)

After power-up the GPIB Service Request (SRQ) will be generated by the 949XP after any error (ex. syntax, output fault, etc.) or depressing the front panel SRQ key. This SRQ output can be inhibited by the SRQ header followed by the single digit "0". The SRQ can be reenabled by the SRQ header followed by 1.

The following example disables the 949XP GPIB SRQ.

SRQ 0

3.6.2.1.13 STEP (STP)

The STP header is used to identify the following argument numeric value as the increment or decrement value for a FRQ, CRL, AMP, PHZ or CAL ramp. Refer to paragraph 3.5.2.9 for additional information.

The following example will ramp all outputs from 130 volts in 1.5 volt/.5 sec. steps to 10 volts.

AMP 130 DLY .5 STP 1.5 VAL 10

3.6.2.1.14 TALK (TLK)

The TLK header is used to set-up the 949XP to talk data. The argument of the TLK header identifies the type of data to be talked in Table 3-6. It can be any parameter, configuration, limit or measurement header identified in Table 3-6.

The response to the arguments CUR, PWR, PWF and VLT are the actual measured outputs.

NOTE

For the response message to be repeated, the 949XP must receive a new TLK string for each of its responses.

TABLE 3-6
TLK ARGUMENTS

ARGUMENT	EXTENTION	DATA	DEFINITION
ALM		RNG,LLM,HLM	TLK ALM will set-up the 949XP to talk the ALM screen when addressed to talk.
CFG		LSN,CFB,PHZ	TLK CFG will set-up the 949XP to talk the CFG screen when addressed to talk.
CUR	A, B, C	Current in amps	TLK CUR will set-up the 949XP to talk the measured current.
ELT		H,M,S	TLK ELT will set-up the 949XP to talk the total accumulated time.
FLM		FRQ,LLM,HLM	TLK FLM will cause the 949XP to talk the FLM screen.
MNU		All headers in vocabulary enabled	TLK MNU will set-up the 949XP to talk all headers of screens enabled.
PWF	A, B, C	0.000 to 1.000	TLK PWF will set-up the 949XP to talk the measured power factor.
PWR	A, B, C	0.000 to 4.000 KW	TLK PWF will set-up the 949XP to talk the measured power.
VLT	A, B, C	Voltage in volts	TLK VLT will set-up the 949XP to talk the measured output voltage.
ANY PROGRAM HEADER			Will set-up the 949XP to talk the programmed value of the Argument.

NOTE: If Extension does not follow the argument, the data will contain A, B and C information.

3.6.2.1.15 TRIGGER (TRG)

The TRG header has no argument. When the TRG mnemonic is included in a setup string to the 949XP it will delay execution of the string until the GPIB Device Trigger message is sent by the bus controller.

The Trigger mode may also be enabled in the local mode by programming setup parameters without depressing the ENT key. The 949XP will then execute the setup values in the remote mode when the Device Trigger is received.

The following example will recall the parameters from register 0 and delay execution until the GET message is received. (Note: GET is the abbreviation for the GPIB Group Execute Trigger message and does not represent a series of ASCII characters).

```
REC 0 TRG
```

3.6.2.1.16 VALUE (VAL)

The header VAL is used to identify the following numeric argument as the final Value of a ramp or step.

If the VAL argument is larger than the initial value for the parameter to be ramped, the ramp will increment with step size defined by STP and DLY. With the VAL argument less than the initial value the ramp will decrement from the initial parameter. Refer to paragraphs 3.5.2.9, 3.6.2.1.5 and 3.6.2.1.13 for additional information.

A ramp or step operation can be stopped at anytime by the GPIB message Group execute trigger.

The following example will decrement the output amplitude of phase A only from 120 in .1 volt/.2 sec. steps to 100 volts after a Device Trigger.

```
AMP A 120 DLY .2 STP .1 VAL 100 TRG
```

The following example will simultaneously ramp the Frequency from 400 to 5000 Hz at a rate of 10 Hz per second and the Amplitude from 5 volts in increments of .5 volts per step:

```
RNG270 AMP5 FRQ400 STP10 DLY 1 VAL5000 STP.5
```

TABLE 3-7
TALK STRING RESPONSE

TLK STRING SENT TO 949XP	RESPONSE FROM 949XP AFTER ADDRESSED TO TALK
TLK ALM	ALM RNG0 LLM135 HLM270
TLK AMP	AMP A005.0 B005.0 C005.0
TLK CAL	CAL A0155 B0188 C0183
TLK CFG	CFG LSN0001 CFB0210 PHZ0120
TLK CLK	CLK INT
TLK CRL	CRL A100.0 B100.0 C100.0
TLK CUR	CUR A00.04 B00.15 C00.16
TLK ELT	ELT H0052 M0027 S0010
TLK FLM	FLM FRQ0400 LLM0045 HLM5000
TLK FRQ	FRQ 400.0
TLK MNU	MNU SNC CLK WVF RNG AMP FRQ PHZ CRL ELT CAL CFG ALM FLM VLT CUR PWR PWF PRG REC DLY STP VAL
TLK PHZ	PHZ A090.0 B240.0 C120.0
TLK PWR	PWR A0.000 B0.000 C0.000
TLK PWF	PWF A1.000 B1.000 C1.000
TLK REG 0	REG 0 ACTUAL CONTENTS OF REGISTOR 0
TLK SNC	SNC INT
TLK VLT	VLT A004.9 B004.9 B005.0
TLK WVF	WVF A SNW B SNW C SNW

3.6.2.1.17 WAVEFORM (WVF)

The header WVF with the optional A, B or C extension is used to identify the following argument as the Sine wave (SNW) or Square wave (SQW) function of the Waveform.

The following example will program all outputs to the square wave function.

WVF SQW

The following example will program only output B to the square wave function:

WVF B SQW

3.6.2.1.18 CURRENT (CUR)

CUR may be used as a header or argument to the header TLK.

When used as an argument, it will set-up the 949XP to measure the output current in amps with 0.01 amp resolution.

When CUR is used as a header in a string with no argument, it will cause the 949XP front panel to display the output current.

3.6.2.1.19 POWER (PWR)

PWR may be used as a header or argument to the header TLK.

When used as an argument, it will set-up the 949XP to measure the output power in kilowatts with 0.001 KW resolution.

When PWR is used as a header in a string with no argument, it will cause the 949XP front panel to display the output power.

3.6.2.1.20 POWER FACTOR (PWF)

PWF may be used as a header or argument to the header TLK.

When used as an argument, it will set-up the 949XP to measure the output power factor from 0 to 1.000 with resolution.

When PWF is used as a header in a string with no argument, it will cause the 949XP front panel to display the output power factor.

3.6.2.1.21 VOLTAGE (VLT)

VLT may be used as a header or argument to the header TLK.

When used as an argument, it will set-up the 949XP to measure the output voltage with 0.1 volts resolution.

When VLT is used as a header in a string with no argument, it will cause the 949XP front panel to display the output voltage.

3.6.2.2 NUMERIC DATA FIELD

Parameter values may be sent to the 949XP as an unsigned value with a decimal point or a decimal point with an exponent. Phase may be sent as a signed value.

3.6.2.2.1 UNSIGNED VALUE WITH DECIMAL POINT

The Decimal Point for numeric data values may be either sent or inferred. The two following ASCII strings will represent 115 volts to the Model 949XP.

AMP115
AMP115.0

There may be any number of digits following the decimal point, not to exceed the 128 byte DMA buffer, but only the Least Significant Digit (LSD) of resolution will be recognized. The LSD for amplitude is tenths of volts. The LSD for frequency is either hundredths, tenths or Hertz for up to 99.99 Hz, 999.9 Hz or 9999 Hz respectively.

3.6.2.2.2 UNSIGNED VALUE WITH DECIMAL POINT AND EXPONENT

Any parameter's numeric value may be of a mixed form with a decimal point and exponent.

The exponent may be a numeric, with or without leading zeros, up to a value of ±63. The following ASCII strings will represent 115 volts to the 949XP:

AMP1.15E2
AMP1.15E+2
AMP1.15E+02
AMP1150E-1

A positive exponent value is represented by either an ASCII "+" or an unsigned value.

3.6.2.2.3 SIGNED VALUE

The phase numeric value may have a + or - sign to correspond to a leading or lagging phase angle with respect to phase A. The following ASCII strings will represent 120.5 degrees for Phase C.

```
PHZC 120.5
PHZC-239.5
PHZC 1.205 E+2
PHZC-2.395 E+2
PHZC+480.5
PHZC-599.5
```

3.6.2.3 MESSAGE SEPARATOR

A complete message consists of a header and an argument. Since more than one message can be sent in a setup string message separators included in the string between the message will make it more readable to the human operator. There are three message separators recognized by the 949XP: the coma (,), semicolon (;), and space. Since these separators are treated as no-ops they may be dispersed throughout a setup string.

The following are two examples of the use of separators:

```
FRQ400;AMPA100,AMPB110,AMPC120;WVF SQW

FRQ,400;AMP,A,100;AMP,B,110;AMP,C,120;WVF,SQW
```

3.6.2.4 DELIMITER

The End of String (EOS) delimiter recognized by the 949XP is the ASCII Carriage Return (CR), Line Feed (LF). The End or Identify (EOI) IEEE-488 message END will also be recognized.

An END or End of String (EOS) message will be recognized by 949XP as a message delimiter.

The END message is sent by setting the IEEE-488 End or Identify line true with the last data byte.

The EOS message will be recognized by the 949XP as the ASCII Carriage Return (CR), Line Feed (LF). The EOS message may be changed to Line Feed (LF) by changing jumper A4W2 to position A4W1. When the jumper is changed to position A4W3 the ASCII Carriage Return will represent the EOS message.

3.6.2.5 NULL CHARACTERS

An ASCII character that can be included anywhere in the setup string without altering the meaning of the string is called a null character.

Whenever the 949XP encounters a null character, it ignores the character. See Table 3-8 for all acceptable ASCII null characters.

TABLE 3-8

NULL (Unexecutable) CHARACTERS

ASCII	HEX	DECIMAL
SP	20	32
,	2C	44
;	3B	59

3.6.3 SERVICE REQUEST

The IEEE-488 Service Request (SRQ) is used by the 949XP to indicate to the bus controller that it needs service.

Any malfunction detected by the 949XP in the remote mode will cause it to generate the SRQ. In addition, the SRQ will be generated in the local control mode by the keyboard SRQ key.

Only operational faults detected in the remote program mode will cause the SRQ to be generated. The operational faults consist of range errors, syntax error, or phase A, B or C faults (See Table 3-9).

3.6.4 STATUS BYTE

Once the bus controller has detected the SRQ it must determine the instrument needing service by the Serial Poll. During the polling routine the instrument needing service will return a Status Byte (STB) greater than decimal 63. As part of the error screen on the 949XP display the 949XP will display the decimal equivalent of the STB with which it will respond. The Status Byte values for various faults are given in Table 3-9.

3.6.5 TRIGGER

The trigger mode of the 949XP is enabled when the mnemonic TRG is added to a setup string. The trigger command may be inserted anywhere in the string. When the mnemonic is detected by the 949XP, it will delay execution of the new setup values until the GPIB Device Trigger is sent by the bus controller.

The trigger mode may also be enabled in the local control mode by programming parameter values without depressing the ENT key. The Model 949XP will then execute the setup values in the remote mode when the Device Trigger is received.

The following setup string will recall the values from register 9 and delay execution until the GET message is received. (note: GET is the abbreviation for the GPIB Group Execute Trigger message and does not represent a series of ASCII characters. (See Table 3-3).

REC9TRG

To set up 0 volts, 400 hertz and wait for GET:

FRQ400AMP0TRG

3.6.6 HEWLETT PACKARD SERIES 80 CONTROLLER PROGRAMMING

For the following program examples the 949XP listen address is "1" and the controller interface is select code "7".

3.6.6.1 SERIES 80 CONTROLLER STATEMENTS

Table 3-8 lists some of the Series 80 Controller statements that may be useful in programming the 949XP on the GPIB. For additional statements and their descriptions refer to the Hewlett Packard I/O Programming Guide for the Series 80 Computer.

3.6.6.1.1 OUTPUT

The following program will step the 949XP program voltage from 0 volts to 130 volts in .1 volt steps:

```
10 REMOTE 7
20 FOR V=0 TO 130 STEP .1
30 OUTPUT 701; "AMP"; V
40 NEXT V
50 END
```

TABLE 3-9

STATUS BYTE VALUES

STATUS BYTE (DECIMAL)	FAULT
64	Phase A
65	Phase B
66	Phase A,B
67	Phase C
68	Phase A,C
69	Phase B,C
70	Phase A,B,C
71	Current Limit
72	Current Limit A
73	Current Limit B
74	Current Limit A,B
75	Current Limit C
76	Current Limit A,C
77	Current Limit C,B
78	Current Limit A,B,C
79	
80	Keyboard Entry 0 SRQ
81	Keyboard Entry 1 SRQ
82	Keyboard Entry 2 SRQ
83	Keyboard Entry 3 SRQ
84	Keyboard Entry 4 SRQ
85	Keyboard Entry 5 SRQ
86	Keyboard Entry 6 SRQ
87	Keyboard Entry 7 SRQ
88	Keyboard Entry 8 SRQ
89	Keyboard Entry 9 SRQ
90	Amplitude Range Limit Error
91	Amplitude Range Error
92	Frequency Range Error
93	Phase Range Error
94	Current Range Error
95	Ramp Range Error
96	Program Syntax Error
97	Bus message sent with Controller in Local
98	EXT SNC Frequency Limit
99	ROM SUM Check Error
100	Exceeds DMA buffer size

TABLE 3-10
HP SERIES 80 CONTROLLER STATEMENTS

STATEMENT	DESCRIPTION
CLEAR 7	Universally sets all instruments to their power-on states by sending the GPIB message DCL
CLEAR 701	Sets only instrument with listen address "1" to its power-on state by sending the GPIB message SDC.
LOCAL 7	Universally sets all instruments into their local control mode by deasserting REN.
LOCAL 701	Sets only instrument with listen address "1" to its local control mode by sending the GTL message.
REMOTE 7	Sets REN true.
REMOTE 701	Sets instrument with listen address "1" to remote.
ABORTIO 7	Clears all instrument interfaces to unlisten and untalk by toggeling IFC.
RESUME 7	Sets ATN false.
OUTPUT 701; "AMP"; V	Sends the data string AMP followed by the numerical value of variable V to the instrument with listen address "1".
STATUS 7,1;A	This statement reads the SR1 register of the series 80 controller for the interrupt cause. This statement is necessary to clear the Service Request flag in the controller.
ENABLE INTR 7; 8	This statement allows the series 80 controller program to be interrupted when a GPIB instrument generates an SRQ.
ON INTR 7 GOSUB100	This statement will cause the program to go to an interrupt subroutine at 100.
TRIGGER 7	This statement triggers all addressed instruments by sending the GET message.
TRIGGER 701	This statement will trigger only the instrument with listen address "1" by sending the GET message.
A=SPOLL (7)	Sets variable A equal to the decimal value of the Status Byte of an instrument previously addressed to talk.
A=SPOLL (701)	Sets variable A equal to the decimal value of the Status Byte of the instrument with listen address "1".

3.6.6.1.2 TRIGGER

The following program will load the parameters of 115 volts and 400 hertz. The Model 949XP will output the parameters only after the K1 special function key of the Series 80 Controller is depressed to send the GET message.

```
10  REMOTE 701
20  OUTPUT 701 ; "AMP115 FRQ400 TRG"
30  ENABLE KBD 32+64 ! ENABLE PAUSE AND SPECIAL FUNCTION KEYS
40  ON KEY # 1 GOTO 100 ! USE KEY K1 FOR DEVICE TRIGGER
50  GOTO 40

100 TRIGGER 701
110 END
```

3.6.6.1.3 SERVICE REQUEST STATEMENTS

The program example for SRQ uses the statements STATUS, ON INTR, ENABLE INTR, and SPOLL.

The LOCAL statement in line 30 puts the 949XP into local.

The STATUS statement in line 40 is necessary to clear the Controller status register from any possible previous Service Request (SRQ) interrupts. The HP I/O Programming Manual is not clear on the use of the STATUS statement but it must be used after every SRQ and before enabling or reenabling the SRQ interrupt to prevent false SRQ indication. Line 50 causes the program to go to the interrupt subroutine at line 100.

The ENABLE INTR statement in line 60 enables the SRQ to generate an interrupt. A worthless program follows in lines 70 and 80 that executes until a SRQ is generated by the 949XP. The SRQ interrupt subroutine is between lines 100 and 210.

The STATUS statement in line 120 clears the SRQ.

Line 130 generates a Status Byte from the 949XP with listen/talk address "1". The variable A will be equal to the value of 80 through 89 for the SRQ keyboard entry of 0 through 9 respectively.

If the value is between 80 and 89 the Status byte value will be displayed with line 170.

Since the 949XP is in the local mode of operation, there will be no other error messages. If the 949XP were left in the Remote mode, other fault messages would be displayed by line 190.

```
20 ! PUT 949XP INTO LOCAL FOR KEYBOARD SRQ
30 LOCAL 701
40 STATUS 7,1;Z ! READ STATUS TO CLEAR HP SERIES 80 STATUS
   REGISTER
50 ON INTR 7 GOSUB 100
60 ENABLE INTR 7;8 ! ENABLE SRQ TO GENERATE INTERRUPT
70 ! SAMPLE PROGRAM TO WAIT FOR SRQ INTERRUPT
80 GOTO 70
100 ! SERVICE REQUEST FOR DEVICE 1

110 ! USE SERIAL POLL TO DETERMINE STATUS BYTE
120 STATUS 7,1;Z ! READ STATUS TO CLEAR SRQ
130 A=SPOLL (701)
140 ! EVALUATE STATUS BYTE TO CHECK FOR SYSTEM FAULT
150 IF A>89 OR A<80 THEN GOTO 190
160 ! KEYBOARD GENERATED STATUS MESSAGE
170 DISP "THE KEYBOARD MESSAGE IS ";A
180 GOTO 200
190 DISP "THE SYSTEM FAULT MESSAGE IS ";A
200 ENABLE INTR 7;8 ! REENABLE INTERRUPT
210 RETURN
```

SECTION 4 - ADJUSTMENT PROCEDURE

4.1 GENERAL

The following adjustment procedure, or any part of it, may be performed on a routine basis to ensure that the 949XP remains within the specified performance limits. Paragraph 4.4 only needs to be performed if a related component has been replaced.

Calibration of the 949XP requires a compatible power source(s) connected as shown in figure 2-1.

4.2 RECOMMENDED TEST EQUIPMENT

Scanner	Keithley Model 705 with Model 7054 card
Digital AC Voltmeter	Keithley Model 192 with Model 1923 IEEE-488 and Model 1910 AC Convertor
Frequency Counter	Philips PM 6671

4.3 PRELIMINARY STEPS

1. Connect the remote sense inputs as shown in Figure 2-1.
2. Apply power to the AC power system and allow at least fifteen minutes for temperature stabilization.
3. Monitor the AC output voltage and frequency at the power source(s) rear panel terminals. Connect channel 1 of the scanner to phase A, channel 2 to phase B and channel 3 to phase C. Connect the scanner card LO to the 949XP sense input LO at J2 pin 3 at the rear panel of the phase A source.

4.4 FREQUENCY ADJUSTMENT

1. Connect the frequency counter across the phase A output.
2. Program 100 volts and 400 Hz.
3. Check that the output frequency is 400.0000 ± .004 Hz.

If the frequency is not within the limit remove power from the power source. Use the Extender Assembly, Part No. 4000-718 to mount the 949XP and install the assembly into the power source.

Locate the adjustment capacitor A3C5 on the left side of the second card from the bottom of the PC card stack.

1. Reapply power to the power source.
2. Reprogram 100 volts and 400 Hz.
3. Adjust A3C5 for 400.0000 Hz.
4. Remove the power to the power source.
5. Reinstall the 949XP without the Extender Assembly.

4.5 OPEN SENSE ADJUSTMENT

1. Open the phase A, B and C sense lines by removing all connections to J2, J3 and J4 at the rear panel of the power source.
2. Program the 949XP to 100 volts. Hold the ENT key depressed - the last key stroke - to prevent the 949XP from defaulting to 5.0 volts.
3. Adjust the phase A, B and C power source gain controls for 110 volts ±.1 volt.
4. Reconnect the remote sense inputs as shown in Figure 2-1.

4.6 FULL SCALE ADJUSTMENT

The full scale adjustment should be made either at 135.0 volts on the 135 volt range or at 270.0 volts on the 270 volt range.

1. Connect the AC voltmeter to the phase to be calibrated.
2. Program 135.0 or 270.0 volts and 400 Hz.
3. Select the CAL screen (12) by selecting the first Menu Screen, then entering the key sequence: 9,4,9,ENT. Next depress the MNU key until the Menu Screen with CAL=12 is displayed. Select the CAL screen with the key sequence: 1,2,ENT.
4. Enter the number 0 and the key A, B or C for the phase to be calibrated.
5. Depress the PRG key followed by the ENT key to begin the calibration routine.
6. When the external AC voltmeter indicates the programmed value depress the ENT key to terminate the CAL routine.

7. Repeat steps 1 through 6 for the other outputs to be calibrated.

8. If it is found that the 949XP ramps the calibration coefficient too rapidly for the external AC voltmeter a delay (DLY) value can be selected on screen 9 before starting the CAL routine.

The following keystroke example will step the phase A calibration coefficient from 10 with the delay for each step of .5 seconds.

First select the CAL screen as described in step 3. Next the keystroke sequence will perform the calibration with a delay:

1,0,A,PRG,9,ENT,A,0,.,5,PRG,ENT

4.7 REMOTE CALIBRATION

The ASCII # symbol can be used with remote calibration to greatly reduce the calibration time.

The ASCII # is used in place of a calibration coefficient to start the CAL ramp to start at the existing CAL coefficient and ramp up or down for a VAL argument of 255 or 0 respectively.

The following string will cause the CAL coefficient to ramp down with a delay of .2 seconds per step:

CAL A # DLY.2 VAL0

4.8 ANALOG TO DIGITAL CONVERTER CALIBRATION (ADC)

This calibration cannot be performed remotely. It must be performed only after the Meter Module has been calibrated and the phase A output has been calibrated.

1. Program the 949XP and its power source to the 270 volts range with an amplitude of 270 volts and 400 Hz.

2. Enter the key sequence 1,6,ENT. Check the value of phase A display.

3. If the phase A value displayed is greater than 270.0, depress the MNU key until the first Menu screen is displayed. Enter the key sequence; 9,4,9,ENT. Depress the MNU key until the screen ADC=20 is displayed.

4. Enter the key sequence; 2,0,ENT. The displayed value will start to decrease. When it displays 270.0, depress the ENT key.

5. If the value displayed in step 3 is less than 270.0, substitute the key sequence in step 3 with 2,0,.,.,ENT. Depress the ENT key when the correct value is displayed.

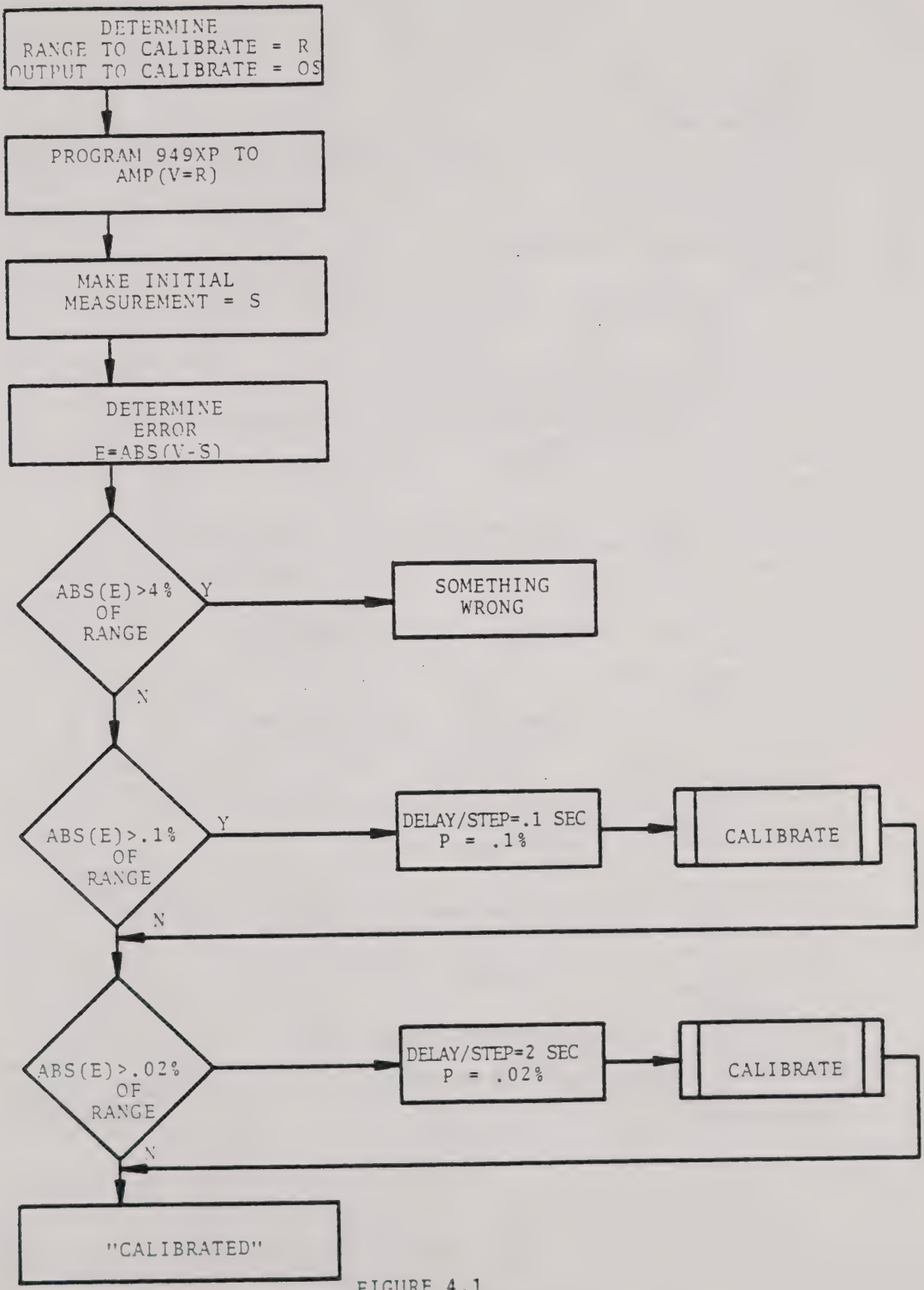


FIGURE 4.1
Remote Calibration
Flow Diagram

```
430 OUTPUT 705 ;"RX"
440 OUTPUT 705 ;"C2X"
450 GOSUB 1000
460 O$="C"
465 OUTPUT 705 ;"RX"
470 OUTPUT 705 ;"C3X"
475 GOSUB 1000
480 LOCAL 7
485 DISP "949XP IS CALIBRATED"
490 END
500 ! CAL SUBROUTINE
510 ! DETERMINE IF OUTPUT IS WITHIN P% OF R
512 WAIT 2000 ! WAIT 2SEC FOR DVM TO SETTLE
515 GOSUB 800
520 IF ABS (E)<P/100*R THEN GOTO 600
530 ! DETERMINE DIRECTION OF CAL COEFF. RAMP
540 IF E<0 THEN C=0 ELSE C=255
545 ON TIMEOUT 7 GOTO 3000
550 OUTPUT 701 ;"CAL";O$;"#DLY";D;"STP";Z;"VAL";C
560 X=255
562 GOSUB 800
564 IF ABS (E)>ABS (X)+.005 THEN GOTO 590
566 IF ABS (E)<P/100*R THEN GOTO 590
568 WAIT D*1000
570 X=E
580 GOTO 562
590 TRIGGER 701 ! STOP CAL RAMP WITH DEVICE TRIGGER
600 RETURN
800 ! MEASURE ROUTINE
810 ENTER 703 ; S
820 S=1.0005*S ! TO COMPENSATE FOR 1K LEAD RESISTANCE
830 E=V-S
840 RETURN
1000 ! GEN CAL
1010 ! PROGRAM 949XP TO SELECTED RANGE AND AMPLITUDE
1020 OUTPUT 701 ;"FRQ400RNG";R;"AMP";V
1030 WAIT 2000 ! WAIT 2SEC FOR DVM TO SETTLE
1040 ON TIMEOUT 7 GOTO 2000
1050 GOSUB 800
1070 IF ABS (E)>.04*R THEN GOTO 3000
1080 D=.1 @ P=.1 @ Z=10 ! DLY=.1SEC FOR CAL TO APPROX. .1%
1090 GOSUB 500
1100 D=1 @ P=.02 @ Z=1 ! DLY=1SEC FOR CAL TO .02%
1110 GOSUB 500
1120 RETURN
2000 DISP "DVM IS INACTIVE. INSURE ADDRESS IS 3."
2010 GOTO 360
3000 DISP "CHECK THAT THE 949XP ADDRESS IS 1."
3010 DISP "THE MEASURED OUTPUT IS ";S
3020 GOTO 360
```

```
10 ! 949XP CAL
20 SET TIMEOUT 7;5000 ! SET BUS TIMEOUT TO 2SEC
30 CLEAR 701 ! SEND SELECTED DEVICE CLEAR TO UNIT ADDRESS 1
40 CLEAR
50 ABORTIO 7
60 R=135
70 O$="A"
80 DISP "THE 949XP ADDRESS MUST BE 1"
90 DISP "THE AC DVM ADDRESS MUST BE 3"
100 DISP "THE SCANNER ADDRESS MUST BE 5"
110 DISP "PRESS K1 TO CONTINUE"
120 ON KEY# 1 GOTO 140
130 GOTO 130
140 OFF KEY#
150 DISP "WHAT VOLTAGE RANGE TO CAL 135 OR 270(DEFAULT IS ";R;")"
160 INPUT C$
170 IF C$ <> "" THEN R=VAL (C$)
174 V=R
176 IF R=270 THEN OUTPUT 703 ;"F1R5X"
178 IF R=135 THEN OUTPUT 703 ;"F1R4X"
180 CLEAR
185 DISP "DO YOU HAVE A SCANNER(Y/N)"
190 INPUT A$
195 IF POS (A$,"Y")=1 THEN GOTO 380
200 IF POS (A$,"N")=1 THEN GOTO 220
210 GOTO 185
220 DISP "WHICH OUTPUT TO CAL(DEFAULT IS ";O$;")"
230 INPUT V$
240 IF V$ <> "" THEN O$=V$
250 CLEAR
260 DISP "CONNECT THE AC DVM TO OUTPUT ";O$;" SELECT AUTORANGE."
270 DISP "PRESS K1 TO CAL."
280 ON KEY# 1 GOTO 300
290 GOTO 290
300 OFF KEY#
310 GOSUB 1000
320 ! OUTPUT CALIBRATED TO WITHIN .02%
330 DISP "OUTPUT ";O$;" CALIBRATED. CAL ANOTHER OUTPUT(Y/N)"
340 INPUT A$
350 IF POS (A$,"Y")=1 THEN GOTO 220
360 LOCAL 7
370 END
380 O$="A"
385 REMOTE 7
390 OUTPUT 705 ;"RX"
400 OUTPUT 705 ;"C1X"
410 GOSUB 1000
420 O$="B"
```

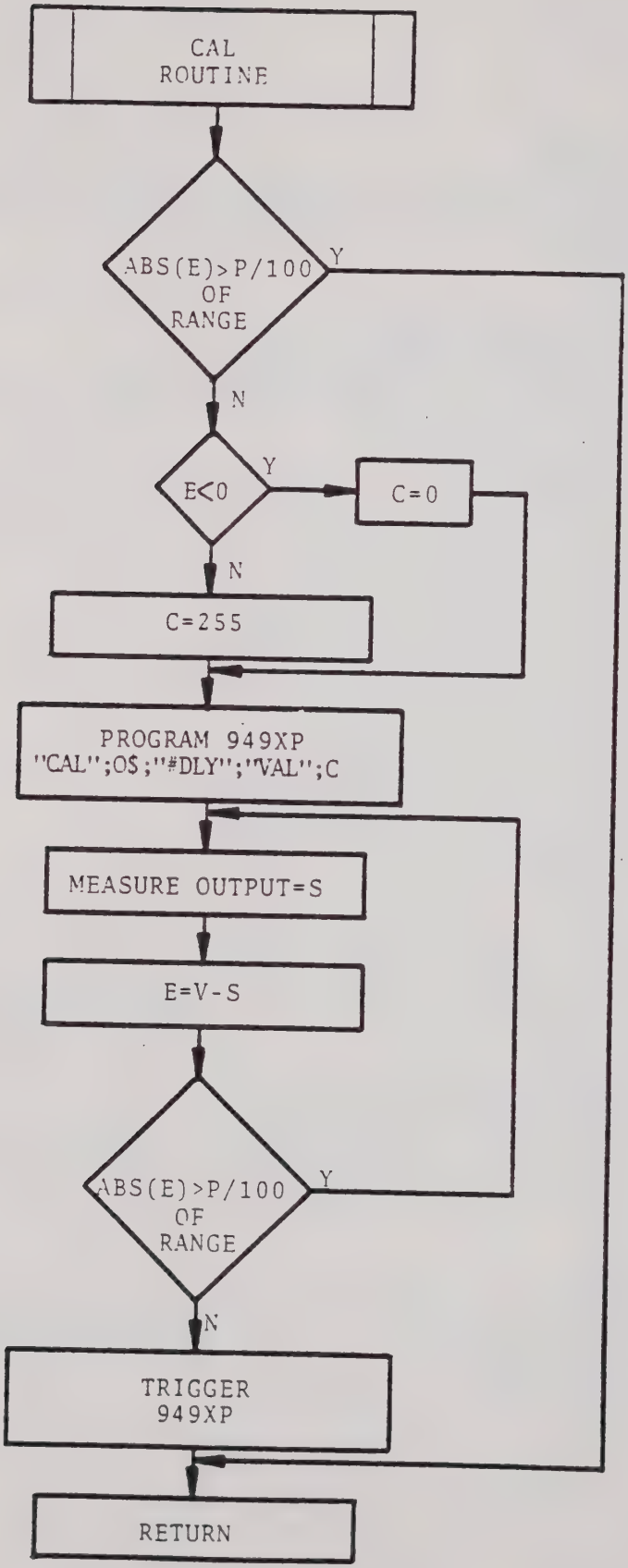


FIGURE 4-2
Calibration Subrouting

SECTION 5 - CIRCUIT DIAGRAMS

5.1 GENERAL

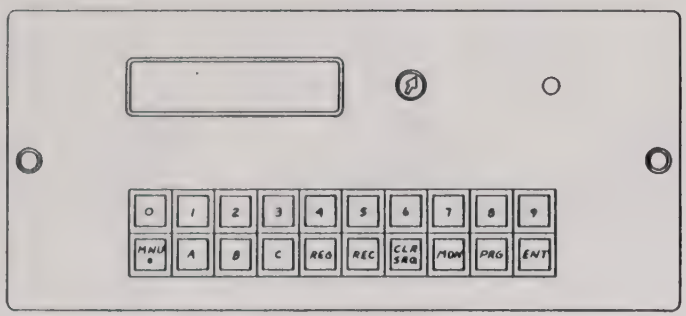
This section of the manual contains schematic and mechanical diagrams necessary for the operation and maintenance of the Model 949XP Power Controller. The schematic diagrams illustrate the circuits while the circuit board assembly diagrams indicate component locations.

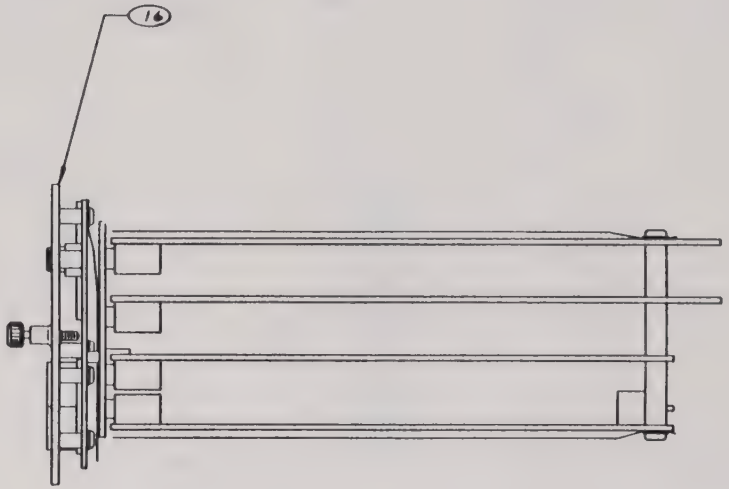
5.2 REFERENCE DESIGNATORS

Partial reference designators are shown on schematic diagrams and circuit board assembly diagrams. Prefix these numbers with assembly and/or subassembly designations for the complete reference designator. Examples follow:

Assembly/Sub-Assembly	Component	Component Designator
None	T1	T1
A1	U6	A1U6
A2	R44	A2R44
A3	C7	A3C7
A4	Q2	A4Q2

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED





4949-405

FOR PARTS, SEE PL 4949-405-1 & -3

ITEM NO	PART OR IDENTIFYING NO	DESCRIPTION	MATERIAL - SPECIFICATION	CODE IDENT	NOTE NO
REQD PER ASSY					

LIST OF MATERIAL

1		949XP	END ITEM
	1	949XP	END ITEM
-3	-1	USED ON	NEXT ASSY
QTY REQD			

NOTES (UNLESS OTHERWISE SPECIFIED)

DIM IN INCHES
TOLERANCES
XXX ± .010
XX ± .03
X° ± 30'

BREAK ALL SHARP CORNERS & EDGES
MACH SURFACES ✓

DWG SIZE C

EXCEPT AS OTHERWISE PROVIDED BY CONTRACT THESE DRAWINGS AND SPECIFICATIONS ARE THE PROPERTY OF CALIFORNIA INSTRUMENTS COMPANY AND SHALL NOT BE REPRODUCED OR COPIED OR USED AS THE BASIS FOR THE MANUFACTURE OR SALE OF APPARATUS WITHOUT WRITTEN PERMISSION

FINISH

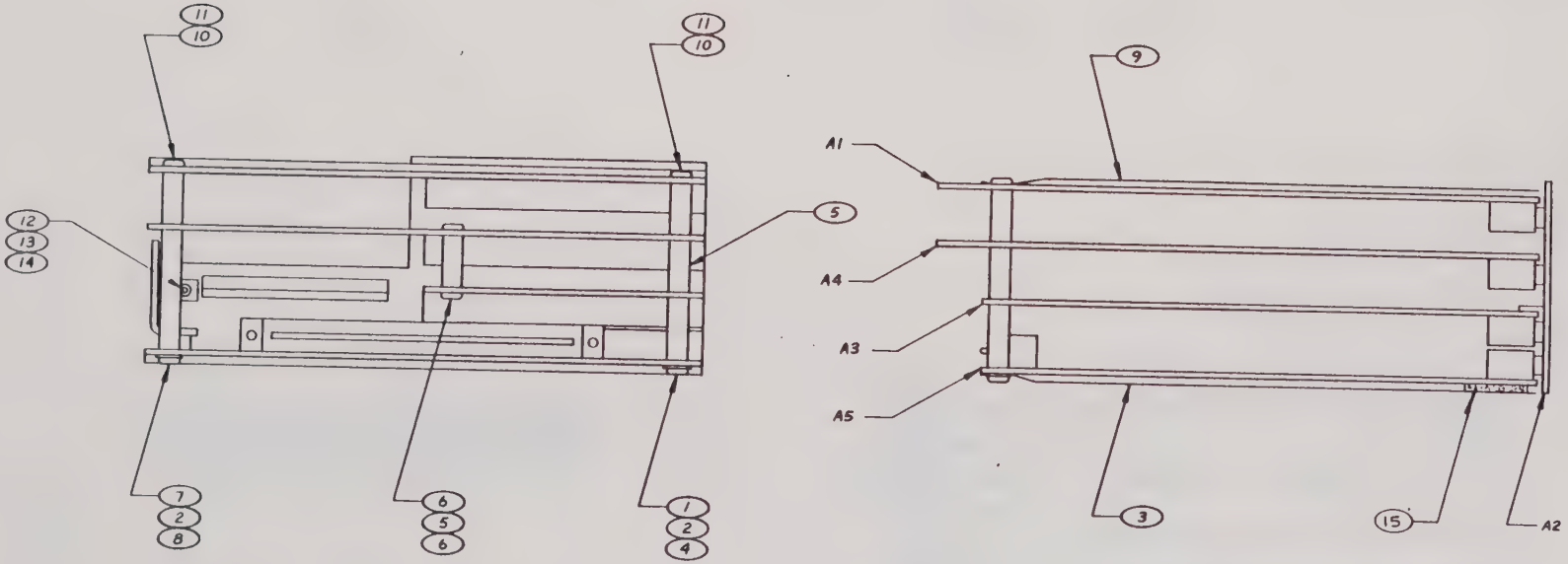
TITLE
TOP ASSY,
PLUG-IN OSC

			ADDITIONAL APPROVALS
RELEASE	R Bidyard	9/19/85	
PROJ ENG	M'FA/DBN	9/85	
CHECK	Erwin E	9/13/85	
DESIGN			
DRAFT	AJ ROBERTO	9 AUG 85	

California INSTRUMENTS
A DIVISION OF AMSTAR TECHNICAL PRODUCTS CO INC
SAN DIEGO CALIFORNIA

CONTRACT NO
CODE IDENT 16067
DWG NO 4949-405
REV
SCALE 1/1
SHEET 1 OF 2

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED



REQD PER ASSY	ITEM NO	PART OR IDENTIFYING NO	DESCRIPTION	MATERIAL - SPECIFICATION	CODE IDENT	NOTE NO

LIST OF MATERIAL

QTY REQD	USED ON	NEXT ASSY

⚠ ITEMS ON P/L MAY DIFFER FROM ITEMS INDICATED IN THIS DWG. WHERE THESE ITEMS DIFFER, USE THE P/L ITEM WHERE DWG ITEM NUMBER IS SHOWN.

NOTES: (UNLESS OTHERWISE SPECIFIED)

DIM IN INCHES
TOLERANCES
XXX ± 010
XX ± 03
X° ± 30'

BREAK ALL SHARP CORNERS & EDGES
MACH SURFACES ✓

DWG SIZE C

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FINISH

TITLE
TOP ASSY,
PLUG-IN OSC

			ADDITIONAL APPROVALS
RELEASE	[illegible]	7/8/85	
PROJ ENG	MCEALDEN	7/85	
CHECK	EEWINE	7/15/85	
DESIGN			
DRAFT	AJROBERTO	20 JUN 85	

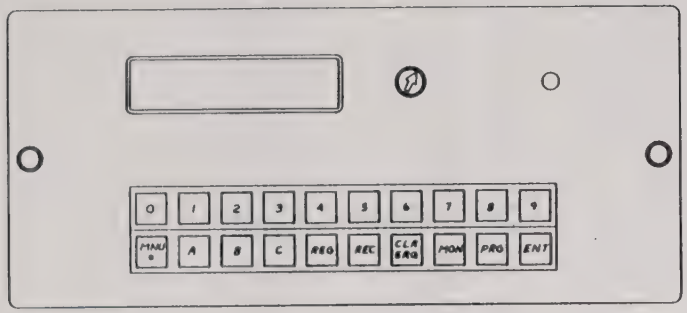
California INSTRUMENTS
A DIVISION OF AMSTAR TECHNICAL PRODUCTS CO INC
SAN DIEGO CALIFORNIA

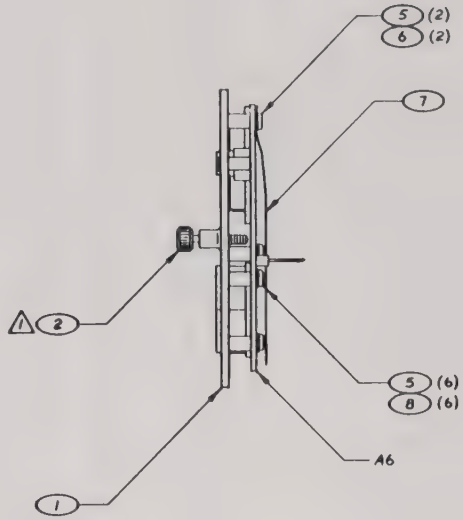
CONTRACT NO
CODE IDENT 16067
DWG NO 4949-405
REV
SCALE 1/1
SHEET 2 OF 2

4949-405

4 3

REV	DESCRIPTION	DATE	APPROVED





FOR PARTS, SEE PL 4949-403-1

ITEM NO	PART OR IDENTIFYING NO	DESCRIPTION	MATERIAL - SPECIFICATION	CODE IDENT	NOTE NO
REQD PER ASSY					

LIST OF MATERIAL

DIM IN INCHES
TOLERANCES
XXX ± 010
XX ± 03
X° ± 30'

BREAK ALL SHARP CORNERS & EDGES
MACH SURFACES ✓

DWG SIZE C

TITLE: FRONT PANEL ASSY

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FINISH

RELEASE	M. Ervine &	9/85
PROJ ENG	M. FADEM	9/85
CHECK	ERWINE	9/13/85
DESIGN		
DRAFT	AUROBERTO	20 JUN 85

ADDITIONAL APPROVALS

California INSTRUMENTS
A DIVISION OF AMSTAR TECHNICAL PRODUCTS CO INC
SAN DIEGO CALIFORNIA

CONTRACT NO
CODE IDENT 16067
DWG NO 4949-403
REV
SCALE 1/1
SHEET 1 OF 1

QTY REQD	USED ON	NEXT ASSY
1	949XP	4949-405-3
1	949XP	4949-405-1
-1		

⚠1 SWAGE ITEM 2 TO ITEM 1 PRIOR TO ALL OTHER ASSEMBLY

NOTES (UNLESS OTHERWISE SPECIFIED)

4949-403

D C B A

4 3 2 1

SECTION 6

REPLACEABLE PARTS

6.1 GENERAL

This section contains ordering information and a complete list of replaceable parts. The parts are listed by their major assembly in alpha-numeric order by their reference designators. The list includes the parts description, manufacturers' identification (see Appendix A for list of manufacturers), and California Instruments' part numbers.

6.2 ORDERING INFORMATION

In order to ensure prompt, accurate service, please provide the following information, when applicable, for each replacement part ordered.

a. Model number and serial number of the instrument.

b. California Instruments part number for the sub-assembly where component is located (PARENT ITEM NO.).

c. Component reference designator (SEQ NO.).

d. Component description (DESCRIPTION TRUNCATED).

e. Component manufacturer's FSCM number (VENDOR).

f. California Instruments part number (COMPONENT ITEM NO.).

A further explanation of these terms can be found in Section 6.3.

All replacement part orders should be addressed to:

California Instruments
Attention: Parts Department
9025 Balboa Avenue
San Diego, California 92123-1509

6.3 COMPUTER GENERATED PARTS LISTS

The following information is included as an explanation of the computer formatted parts list column.

6.3.1 "SEQ NO." - Sequence Number: the reference designator or the component, or (if there is no reference designator) the balloon number (bubble or "find" number) on the face of the assembly drawing or the top assembly drawing. They are listed in alpha-numeric order.

6.3.2 "COMPONENT ITEM NO." - This is California Instruments' part number. Please use this number when ordering spares or replacements.

6.3.3 "DESCRIPTION TRUNCATED" - A brief description of the item. The abbreviations are per MIL-STD-12 or industry accepted standards.

6.3.4 "ENGINEERING DRAWING NUMBER" - This is used for one of the following:

a. The document/specification number generated by California Instruments to control the part.

b. The generic part number (military specifications or industry accepted standard).

c. The primary vendor's catalog part number. An asterisk at the end of the number indicates number is longer than that shown. (Contact California Instruments if the full number is required.)

6.3.5 "VENDOR" - This is the FSCM code to identify the manufacturer. (See Appendix A).

6.3.6 "QTY" - This is the Quantity and Unit of Measure used in the assembly. The Unit of Measure abbreviations are per MIL-STD-12 or industry accepted standard.

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NO.	VENDOR	QTY	UM
A2	4949-710-1	PC ASSY,MOTHER	4949-710	16067	1.0	EA
A3	4949-708-1	PC ASSY,VOLT/FREQ REF	4949-708	16067	1.0	EA
A4	4949-705-1	PC ASSY,CPU/INTERFACE	4949-705-REV H	16067	1.0	EA
A5	4949-706-1	PC ASSY,PHASE A	4949-706-REV E	16067	1.0	EA
1	210171	SCREW,PNH,S/S,6-32X1-1/	MS51957-35	96906	1.0	EA
2	FS1080	WASHER,FLAT,S/S,#6	MS15795-806	96906	2.0	EA
3	4949-209-1	INSULATOR,PWB	4949-209-1	16067	1.0	EA
4	210258	SPACER, #6 X 3/4"	2103	83330	1.0	EA
5	210773	STANDOFF,6-32 X 5/8",PH	8158-PH-0632	06540	2.0	EA
6	FS1028	SCREW,PNH,S/S,6-32X5/16	MS51957-27	81349	2.0	EA
7	FS1038	SCREW,PNH,S/S,6-32X1	MS51957-34	96906	1.0	EA
8	210847	STANDOFF,6-32 X 1 7/16	8168-PH-0632	06540	1.0	EA
9	4949-208-1	INSULATOR,PWB	4949-208-1	16067	1.0	EA
10	FS1028	SCREW,PNH,S/S,6-32X5/16	MS51957-27	81349	2.0	EA
11	FS1080	WASHER,FLAT,S/S,#6	MS15795-806	96906	2.0	EA
12	210283	SCREW,PNH,S/S,2-56X1/4	MS51957-3	81349	1.0	EA
13	210101	WASHER,SPLT,#2	MS35338-134	81349	1.0	EA
14	FS1105	WASHER,FLAT,S/S,#2	MS15795-802	81349	1.0	EA
15	FS4014	TAPE,FOAM,DOUBLE ADHESI	3/4WIDEX1/8DEEP	81349	12.0	IN
16	4949-403-1	FRONT PANEL ASSY	4949-403 REV A	16067	1.0	EA

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NO.	VENDOR	QTY	UM
A1	4949-707-1	PC ASSY,PHASE B/C	4949-707	16067	1.0	EA
A2	4949-710-1	PC ASSY,MOTHER	4949-710	16067	1.0	EA
A3	4949-708-1	PC ASSY,VOLT/FREQ REF	4949-708	16067	1.0	EA
A4	4949-705-1	PC ASSY,CPU/INTERFACE	4949-705-REV H	16067	1.0	EA
A5	4949-706-1	PC ASSY,PHASE A	4949-706-REV E	16067	1.0	EA
1	210171	SCREW,PNH,S/S,6-32X1-1/	MS51957-35	96906	1.0	EA
2	FS1080	WASHER,FLAT,S/S,#6	MS15795-806	96906	2.0	EA
3	4949-209-1	INSULATOR,PWB	4949-209-1	16067	1.0	EA
4	210258	SPACER, #6 X 3/4"	2103	83330	1.0	EA
5	210773	STANDOFF,6-32 X 5/8",PH	8158-PH-0632	06540	2.0	EA
6	FS1028	SCREW,PNH,S/S,6-32X5/16	MS51957-27	81349	2.0	EA
7	FS1038	SCREW,PNH,S/S,6-32X1	MS51957-34	96906	1.0	EA
8	210847	STANDOFF,6-32 X 1 7/16	8168-PH-0632	06540	1.0	EA
9	4949-208-1	INSULATOR,PWB	4949-208-1	16067	1.0	EA
10	FS1038	SCREW,PNH,S/S,6-32X1	MS51957-34	96906	2.0	EA
11	210774	SPACER, #6 X 5/8",PHEN	9230-PH-140	06540	2.0	EA
12	210283	SCREW,PNH,S/S,2-56X1/4	MS51957-3	81349	1.0	EA
13	210101	WASHER,SPLT,#2	MS35338-134	81349	1.0	EA
14	FS1105	WASHER,FLAT,S/S,#2	MS15795-802	81349	1.0	EA
15	FS4014	TAPE,FOAM,DOUBLE ADHESI	3/4WIDEX1/8DEEP	81349	12.0	IN
16	4949-403-1	FRONT PANEL ASSY	4949-403 REV A	16067	1.0	EA

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NO.	VENDOR	QTY	UM
A6	4949-709-1	PC ASSY,KEYBOARD	4949-709 REV C	16067	1.0	EA
DS2	250392	LAMP,LED,RED	MV57124	72699	1.0	EA
1	4949-206-1	PANEL,FRONT W/4949-206	4949-206-1	16067	1.0	EA
2	240325	FSTNR,CAPTIVE SCREW	51-28-506-24	94222	2.0	EA
5	FS1011	SCREW,PNH,S/S,4-40X1/4	MS51957-13	96906	8.0	EA
6	FS1079	WASHER,FLAT,S/S,#4	MS15795-804	96906	2.0	EA
7	4949-207-1	INSULATOR,KEYBOARD	4949-207-1	16067	1.0	EA
8	FS1072	WASHER,SPLT,S/S,#4	MS35338-135	96906	6.0	EA

Appendix A

Number	Vendor Name	City	State
0000A	Electricord	Westfield	PA
0000C	Jackson Bros.	Wadden,Surrey	GB
0000S(28564)	OPCDA (Relac Elect. Corp.)	Winsted	CT
0000W	Milton Ross Co.	Southampton	PA
00001(52745)	Timco	Los Angeles	CA
000AC	Itac	Santa Clara	CA
000AD(55112)	Pleasey (Westlake Cap. Inc.)	Westlake Village	CA
000AG	Lafrance	Philadelphia	PA
000AH(54363)	Jan Crystal	Ft. Myers	CA
000AL(53495)	Data Components, Inc.	Gardena	CA
000AM	Kraus & Helmer	Santa Monica	CA
000AN	Ritz Instrument Transformer	Redondo Beach	CA
000AS	Switches Incorporated	Mt. View	CA
000AT(62643)	United Chemi-Con	Rosemont	IL
000AU	JMJ Technical Prod. Inc.	Kendall Park	NJ
000AV(61837)	Semi Processes, Inc.	San Jose	CA
000AW	Hirose	Chatsworth	CA
000AX(63078)	Aptronics	Mentor	OH
000AY	Silicon Power Cube Corp.	Long Beach	CA
000AZ(61271)	Fujitsu	Santa Clara	CA
000BA(61964)	Omron Electronics, Inc.	Schaumburg	IL
000BB	Hallmark Metals, Inc.	Glendora	CA
000BC	Toshiba America, Inc.	Tustin	CA
000BD(55982)	Electronic Essentials	Woodside	NY
000BE(57856)	Kel-Am	Eldon	MO
000BF(55285)	Berquist	Minneapolis	MN
000BG	Panasonic	Secaucus	NY
000BH	Century Components	Canyon Country	CA
000BI(54186)	Micro Power Systems	Santa Clara	CA
000BJ(06776)	Robinson Nugent	New Albany	IN
000BL(13150)	Beau Products (Vernitron)	Laconia	NH
000BM(91725)	Corebinder (Gerrard AJ & Co.)	Des Plaines	IL
000BO	Mitsubishi Electronics Amer.	Sunnyvale	CA
000BP	Silicon Power Cube	Long Beach	CA
000BR	Secme	Bagnolet	France
000BS	Panel Components Corp.	Santa Rosa	CA
00544	Metal-Cal Div., Avery Prod.	Inglewood	CA
00779	AMP Inc.	Harrisburg	PA
00853	Sangamo Electronic Co.	Pickens	SC
00866	Goe Eng. Co., Inc.	City of Industry	CA
01002	G.E. Co., Ind. & Pwr. Cap. Dept.	John St. Hudson Falls	NY
01121	Allen-Bradley Co.	Milwaukee	WI
01139	G.E. Co., Silicone Prod.	Waterford	NY
01295	Texas Instruments	Dallas	TX
01961	Pulse Engineering, Inc.	San Diego	CA
02111	Spectrol Electronics	City of Industry	CA
02113	Collcraft, Inc.	Cary	IL
02335	Fairchild Controls Corp.	Hicksville,LI	NY
02395	American Insulating Mach. Co.	Philadelphia	PA
02538	Texas Electronics Co.	Dallas	TX
02660	Amphenol Corporation	Broadview	IL
02768	Illinois Tool Works, Inc.	Des Plains	IL
02799	Use Code 172136		
03507	General Electric Company	Syracuse	NY
03508	General Electric Company	Syracuse	NY
03797	Eldema Corporation	Compton	CA
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls	NJ
03911	Claitex Corporation	New York	NY
04009	Arrow-Hart and Hegeman Elec.	Hartford	CT
04099	Capco, Inc.	Grand Junction	CO
04713	Motorola Semiconductor Prod.	Phoenix	AZ
04729	Universal Components Corp.	Green Brook	NJ
04963	J-M	St. Paul	MN
05245	Corcom Inc.	Chicago	IL
05276	Pomona Electronics., Inc.	Pomona	CA
05397	Kemet, Union Carbide Corp.	Cleveland	OH
05791	Lyn-Tron, Inc.	Burbank	CA
05820	Wakefield Engineering, Inc.	Wakefield	MA
05972	Loctite Corp.	Newington	CT
06383	Panduit Corp.	Tinley Park	IL
06514	Stantron, Wyco Metal Prod.	N. Hollywood	CA
06540	Amatom Elect. Hardware	New Rochelle	NY
06665	Precision Monolithics Inc.	Santa Clara	CA
06776	Robinson Nugent, Inc.	New Albany	IN
06915	Richco Plastics, Co.	Chicago	IL
07088	Kelvin Electric Company	Van Nuys	CA
07263	Fairchild Camera & Instr.	Mt. View	CA
07387	Birtcher Corporation	Los Angeles	CA
07556	Unitrack Calabro Plastics	Upper Darby	PA
07633	Epoxy Prod. Co., Allied Prod. Corp.	New Haven	CT
07707	USM Corp. (USM Fastener Div)	Shelton	CT
07716	IRC Incorporated	Burrington	IA
07910	Use Code 41581#		
08028	Loctite (Auto & Consumer Grp)	Mtn View	CA
08057	Spang Ind. (Magnetics Div)	Sandy Lake	PA
08065	Accurate Rubber and Plastics	San Diego	CA
08261	Spectra Strip (Amphenol)	Garden Grove	
08289	Bilnt Gilbert Co.	Pomona	CA
08353	Bristol Co. of Canada	Toronoto, Ont	Canada
08730	Ostby & Barton (Vemaline Prod. Div.)	Warwick	RI
08779	Signal Transformer	Brooklyn	NY
09214	GE (Semiconductor Prod. Div)	Auburn	NY
09353	C & K Components	Newton	MA
09922	Burndy Corp.	Norwack	CT
10389	Chicago Switch	Chicago	IL
11815	Cherry/Textron (Fastener Div)	Santa Ana	CA
12406	Elpac Electronics	Santa Ana	CA
12697	Clarostat Mfg.	Dover	NH
13103	Thermalloy Company	Dallas	TX
13150	Vernitron Corp (Beau Prod.)	Laconia	NH
13604	Sperry Corp. Elec. Systems	Great Neck	NY
13919	Burr-Brown	Tucson	AZ
14099	Semtech Corporation	Newbury Park	CA
14604	Elmwood Sensors Inc.	Cranston	RI
14655	Cornell-Dubilier Elect. Corp.	Newark	NJ
14726	Hollingsworth Co.	Phoenixville	PA
14752	Electro Cube, Inc.	San Gabriel	CA
14908	Electronic Instrument and Specialty Corp.	Stoneham	MA
15238	ITT Semiconductors	Lawrence	MA
15454	Ametek Enk (Rodan Div)	Anaheim	CA
15636	Elec-trol	Northridge	CA
15801	Fenwall Electronics	Framingham	MA
15818	Ameico Teledyne, Inc.	Mt. View	CA
15912	Analey	Los Angeles	CA
16087	California Instruments Co.	San Diego	CA
16758	Delco Radio Div., Gen. Mtrs.	Kokomo	IN
16956	Dennison	Framingham	MS
17856	Siliconix, Inc.	Santa Clara	CA
18076	Umpco	City of Industry	CA
18178	Vactec, Inc.	Maryland Heights	MO
18310	Concord Electronics Corp.	New York	NY
18324	Signetics	Sunnyvale	CA
18612	Vishay Instruments, Inc.	Malvern	PA
18677	Scambe Mfg. Co. (Zero Corp.)	Monterey Park	CA
18722	RCA	Mountaintop	PA
18736	Voltronics Corp.	Hanover	NJ
19080	Robinson Company	Hawthorne	CA
21604	Buckeye Stamping Company	Columbus	OH
21845	Solitron Devices (Semi-conductor Group)	Riviera Beach	FL
22599	Elastic Stop Nut Corp.	Van Nuys	CA
23050	Product Components Corp.	Bastings-on-Hudson	NY
23936	Pamotor, Inc.	San Francisco	CA
24011	ECC	Burlington	MA
24355	Analog Devices, Inc.	Norwood	MA
24444	General Semiconductor Inc.	Tempe	AZ
24796	Pareico, Inc.	Paramount	CA
24931	Specialty Connector Co., Inc.	Greenwood	IN
24972	AEG-Telefunken Corp.	Summerville	NJ
25403	Amperex Electronic Corp.	Slaterville	RI
25497	Meter Master	Los Angeles	CA
26405	Marathon Electric Mfg. Corp.	Bowling Green	OH
26806	American Lectier, Inc.	Costa Mesa	CA
27014	National Semi-Conductor Crp.	Santa Clara	CA
27191	Cutler-Hammer, Inc.	Milwaukee	WI
27264	Noiles	Downers Grove	IL
27335	B & B Motor & Control Corp.	New York	NY
27556	IMB Electronic Products	Santa Fe Springs	CA
27683	Varo, Inc.	St. Garland	TX
27735	F-Dyne Electronics	Bridgeport	CT
27832	Hughes Aircraft	Newport Beach	CA
28480	Hewlett-Packard Co.	Palo Alto	CA
28520	Heyman Mfg. Company (Heyco)	Kenilworth	NJ
28606	Echlin Ltd.	Rexdale Ont.	Canada
29372	Rexnord Inc. Tridair Ind.	Torrance	CA
29593	Bussco Eng. Inc.	El Segundo	CA
30039	International Components Crp.	Asbury Park	NJ
30161	Aavid Engineering, Inc.	Laconia	NH
30897	Dorann Company	Sylmar	CA
30983	Electra/Midland (Mepco/ Electra)	San Diego	CA
31827	Budwig Mfg. Co.	Ramona	CA
31951	Tridige, Inc.	Pittsburg	PA
32293	Intersil	Cupertino	CA
32559	Bivar, Inc.	Santa Ana	CA
32997	Bourns Inc. (Trimpot Div)	Riverside	CA
33005	Jewell Electrical Inst. Inc.	Manchester	NH
33335	Logic Dynamics, Inc.	Gardena	CA
33716	Kingsbacher Murray Co.	Los Angeles	CA
33855	Ducommun, Inc.	Los Angeles	CA
33901	Colber Corp.	Irvington	NJ
34238	Mills Resistor Co.	Los Alamitos	CA
34333	Silicon General	Westminster	CA
34649	Intel Corporation	Santa Clara	CA
35007	Aerovox Canada Ltd.	Amherst NS	Canada
37964	Linear Technology, Inc.	Burlington, Ont	CAN
44655	Ohmite Manufacturing Co.	Skokie	IL
45722	Parker-Kalon	Clifton	NJ
46384	Penn. Eng. and Mfg. Corp.	Doylestown	PA
50157	Midwest Components, Inc.	Muskegon	MI
50522	Monsanto, Electronic Special Products	Cupertino	CA
50558	Electronic Concepts, Inc.	Eatontown	NJ
50811	Mouser Corp.	Santee	CA
51167	Acies Electronics, Inc.	Frenchtown	NJ
51506	Accurate Screw Machine Co.	Mutley	NJ
51705	ICO/Rally	Palo Alto	CA
52072	Circuit Assembly Corp.	Costa Mesa	CA
52745	Timco	Los Angeles	CA
53076	Kintex, Inc.	Buffalo	NY
53495	Data Components, Inc.	Gardena	CA
54361	Edwards Sheet Metal Works	Fredericktown	OH
54407	Power-One Co.	Camarillo	CA
55222	Sastek, Inc.	New Albany	NY
55566	RAF Electronic Hardware, Inc.	Seymour	CT
56289	Sprague Electric Company	North Adams	MA
56637	RCD Components, Inc.	Manchester	NH
57640	United Chem-Con Corp.	Philadelphia	PA
57856	Kel-Am, Inc.	Eldon	MO
58474	Superior Electric Company	Bristol	CT
59730	Thomas and Betts Company	Elizabeth	NJ
59993	International Rectifier Semiconductor Div.	El Segundo	CA
60395	Xicor, Inc.	Milditas	CA
61394	Seeq Technology, Inc.	San Jose	CA
61441	Saronix	Palo Alto	CA
61528	Aromat Corp.	Mountainside	NJ
61735	Pulse Engineering, Inc.	College Park	MD
62483	Densitron Corp. of America	Torrance	CA
62643	United Chemicon, Inc.	Rosemont	IL
62786	Nitachi America Ltd.	San Jose	CA
63743	Ward Leonard Electric Co.	Mt. Vernon	NY
63791	Star Micronics, Inc.	New York	NY
70318	Allmetal Screw Prod. Co.	Garden City	NY
70903	Belden Manufacturing Co.	Chicago	IL
71218	Bud Industries, Inc.	Willoughby	OH
71279	Cambridge Thermionic Corp.	Camoridge	MA
71400	Bussman Mfg. Div. McGraw-Edison Co.	St. Louis	MO
71450	CTS Corporation	Elkhart	IN
71468	ITT Cannon Electric, Inc.	Los Angeles	CA
71590	Centralab Div. Globe-Union	Milwaukee	WI
71707	Corcom/Gence	Pawtucket	RI
71744	Chicago Miniature Lampworks	Chicago	IL
71785	Cinch Manufacturing Company	Chicago	IL
71984	Dow Corning Corp.	Midland	MI
72136	Elmenco (Electro Motive)	Williamantic	CT
72619	Dialight Corporation	Brooklyn	NY
72699	General Instruments	Newark	NJ
72982	Erie Technological Prod. Inc.	Erie	PA
73138	Beckman Instruments, Inc.	Anerrton	CA
73612	Consolidated Electronic Wire and Cable Corp.	Chicago	IL
73734	Federal Screw Products, Inc.	Chicago	IL
74193	Heinemann Electric Company	Trenton	NJ
74545	Harvey Hubbell, Inc.	Bridgeport	CT
74840	Illinois Condenser Co.	Chicago	IL
74970	E.F. Johnson Company	Waseca	MN
75042	TRW Electronic Components	Philadelphia	PA
75382	Kulka Electric Corporation	Mt. Vernon	NY
75582	Leviton Mfg. Co.	Little Neck	NY
75915	Littlefuse, Inc.	Des Plaines	IL
76385	Minor Rubber Co., Inc.	Bloomfield	NJ
77062	Pabst Eng. Equipment Co.	Elizabeth	NJ
77132	United-Carr Inc., Patwin Div	Waterbury	CT
77342	Potter and Blumfield Div, AMF	E. Princeton	IN
78189	Shakeproof Div, IL Tool Works	Chicago	IL
78553	Tinnerman Products, Inc.	Cleveland	OH
79130	Johns-Manville Products Corp	Chicago	IL
79136	Waldes Kohinoor Inc.	Long Island City	NY
79963	Zierick Mfg. Corp.	New Rochelle	NY
80031	Mepco/Electra	Morristown	NJ
80223	United Transformer Co.	New York	NY
80294	Bourns, Inc.	Riverside	CA
80495	High Voltage Engineering Corp (Anderson Pwr Prod. Div)	Brighton	MA
81095	Triad Transformer Corp.	Venice	CA
81312	Winchester Electronics	Oakville	CT
81348	(Fed. Specs) Promulgated by General Services Administration Washington DC		
81349	Military Specification or Commercial Generic Number		
81541	Airpax Corp.	Cambridge	MD
81603	Reco Products Co.	Chicago	IL
81851	Bentley-Harris Mfg Co.	Lionville	PA
82104	Standard Grigsby	Aurora	IL
82389	Switchcraft, Inc.	Chicago	IL
82877	Rotron Mfg. Co., Inc.	Woodstock	NY
82893	Vector Electronics, Inc.	Sylmar	CA
83330	Herman H. Smith, Inc.	Brooklyn	NY
83486	Elco Tool & Screw Corp.	Rockford	IL
85480	Brady W.H. Co.	Milwaukee	WI
86684	RCA	Harrison	NJ
86928	Seastrom Mfg. Co., Inc.	Glendale	CA
87034	Marco-Oak Industries	Anaheim	CA
88245	Useco Div., Litton Ind.	Van Nuys	CA
90201	Mallory Capacitor Co.	Indianapolis	IN
91506	Augat, Inc.	Attleboro	MA
91637	Dale Electronics, Inc.	Columbus	NE
91662	Elco Corporation	Willow Grove	PA
91802	Industrial Devices, Inc.	Edgewater	NJ
91833	Keystone Electronics Corp.	New York	NY
91967	National Tel-Tronics	Meadville	PA
92194	Alpha Wire Corp.	Elizabeth	NJ
93303	Pentagon Products Co.	Washington	DC
94222	Southco, Inc.	Lester	PA
94686	Magnecraft Electric Co.	Chicago	IL
95144	Alco Electronic Prod., Inc.	No. Andover	MA
95303	RCA	Cincinnati	OH
95354	Methode Manufacturing Corp.	Rolling Meadows	IL
95566	Arnold Engineering Co.	Marengo	IL
95587	Wechsler Company, Inc.	Chicago	IL
96906	Military Std		
97525	Electronic Engineering Co.	Santa Ana	CA
98159	Rubber Teck, Inc.	Gardena	CA
98291	Sealectro Corp.	Mamaroneck	NY
98376	Zero Mfg. Co. (West)	Burbank	CA
98978	IERC	Burbank	CA
99017	Protective Closures Co., Inc. (Capinge Div)	Buffalo	NY
99217	Bell Industries, Inc.	Delavan	WI
99742	Permacell	New Brunswick	NJ
99743	IMC	Maywood	CA
99800	Delevan Electronics Corp.	Aurora	NY

ONE YEAR WARRANTY

CALIFORNIA INSTRUMENTS CORPORATION warrants each instrument manufactured by them to be free from defects in material and workmanship for a period of one year from the date of shipment to the original purchaser. Excepted from this warranty are tubes, fuses, and batteries which carry the warranty of their original manufacturer where applicable. CALIFORNIA INSTRUMENTS will service, replace, or adjust any defective part or parts, free of charge, when the instrument is returned freight prepaid, and when examination reveals that the fault has not occurred because of misuse, abnormal conditions of operation, user modification, or attempted user repair. Equipment repaired beyond the effective date of warranty or when abnormal usage has occurred will be charged at applicable rates. CALIFORNIA INSTRUMENTS will submit an estimate for such charges before commencing repair, if so requested.

PROCEDURE FOR SERVICE

If a fault develops, notify CALIFORNIA INSTRUMENTS or its local representative, giving full details of the difficulty, including the model number and serial number. On receipt of this information, service information or a Return Material Authorization (RMA) number will be given. Add RMA No. to shipping label. Pack instrument carefully to prevent transportation damage, affix label to shipping container, and ship freight prepaid to the factory. CALIFORNIA INSTRUMENTS shall not be responsible for repair of damage due to improper handling or packing. Instruments returned without RMA No., or freight collect will be refused. Instruments repaired under Warranty will be returned by prepaid surface freight. Instruments repaired outside the Warranty period will be returned freight collect, F.O.B. CALIFORNIA INSTRUMENTS, San Diego, CA. If requested, an estimate of repair charges will be made before work begins on repairs not covered by the Warranty.

DAMAGE IN TRANSIT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed immediately with the carrier. A full report of the damage should be obtained by the claim agent, and a copy of this report should be forwarded to us. CALIFORNIA INSTRUMENTS will prepare an estimate of repair cost and repair the instrument when authorized by the claim agent. Please include model number and serial number when referring to the instrument.

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